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DEPARTMENT OF AGRICULTURE.
BOTANICAL DIVISION.
BULLETIN NO. ~~II.~~ 2.
SECTION OF PLANT PATHOLOGY.

REPORT

ON THE

FUNGUS DISEASES

OF THE

GRAPE VINE.

BY

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PREPARED UNDER THE DIRECTION OF THE COMMISSIONER OF AGRICULTURE.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1886.

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ERRATA.

Page 5, second paragraph, read "Les Maladies de la Vigne, *by Viala.*"

Page 5, second paragraph, read "Le Black Rot, by *Viala and Ravaz.*"

Page 13, read "Les Maladies de la Vigne" in foot-note.

Page 17, line 10, read "Bellussi."

Page 17, line "the Commissioner," insert comma after word "Agriculture."

Page 17, line "fruits are dangerous," insert comma after word "foliage."

Page 18, third line from bottom, read "Vinifera."

Page 35, line "of the subject," for "*Maladies des Vignes*", read *Les Maladies de la Vigne.*

Page 40, line 19, and in ⅔ foot note, for "*Maladies des Vignes*", read *Les Maladies de la Vigne.*

Page 41, line "affected leaves," read "Sphæriaceous."

Page 122, under explanation of Fig. 15, for "Les Maladies des Vignes", read Les Maladies de la Vigne.

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UNITED STATES DEPARTMENT OF AGRICULTURE,
DIVISION OF BOTANY, SECTION OF PLANT PATHOLOGY,
Washington, D. C., November 10, 1886.

SIR: I have the honor to submit herewith my report on "The Fungus Diseases of the Vine," prepared in accordance with your instructions.

I have made as careful a study of the principal fungi injurious to the vine in this country as possible in so short a time, and, to give additional value and interest to the report, I have consulted and made frequent use of the papers by Dr. W. G. Farlow on *The Peronospora and Uncinula of the Vine*, and also the works of several French authors, as *Le Peronospora des Vignes*, by Maxime Cornu; *Les Maladies de la Vigne*, by Viala and Ravaz, and *Le Black Rot*, by Foëx and Viala.

With the circular of proposed remedies for combating the Downy Mildew and the Black rot, sent out by this Department in May last, there was a circular of inquiries having for its object the obtaining of a more definite knowledge of the distribution of these diseases in the United States, and the actual extent of the losses they occasioned. Nearly four hundred of these latter circulars were returned, and the information gained through them has been compiled by my assistant, Mr. Erwin F. Smith, and appears in Appendix A.

The paper by Col. Alexander W. Pearson, of Vineland, N. J, to which public attention was called in the last annual report of this Department, forms Appendix B. This paper, coming from one of the foremost of our practical vineyardists, and one who has given long and careful attention to the subject of which he treats, I deem especially valuable, and I am certain it will be read with great interest by all practical grape-growers.

Since the appearance of the Downy Mildew in France in 1878, its ravages have increased in that country and extended throughout the grape-growing regions of Central and Southern Europe to such an alarming extent as to call for the exercise of every effort on the part of individuals and Governments to check or destroy it.

Experiments with remedies and preventives, begun in 1882, have been continued systematically in European vineyards, and the results obtained in 1885 appear to have been so decisive and satisfactory that a detailed account of these operations cannot fail to be of interest to the American vineyardist, and a translation of the more important

papers upon preventives or remedies for the Downy Mildew, which have recently appeared in the French and Italian viticultural journals, has been made and will be found in Appendix C.

It probably is too early to speak positively of the value of these remedies under the different climatic and soil conditions of the United States, but an account of them will certainly stimulate investigation among our grape-growers, and at the same time serve to indicate the lines along which investigations can be most successfully prosecuted.

An extended series of carefully-conducted experiments must be made in this country before these remedies can be presented to the grape-growing public with unqualified recommendation; this is particularly true of that class of remedies which contain the poisonous salts of copper. Such a series of experiments, made on a scale so large and at points so widely distant as to give them a general and practical value, has been planned as a part of the work of this section for next season.

F. LAMSON SCRIBNER,
Special Agent.

Hon. NORMAN J. COLMAN,
Commissioner of Agriculture.

THE FUNGUS DISEASES OF THE GRAPE VINE.

Two special works of a scientific character on the fungi of the vine were published several years ago.* In the first, 104 species, or so-called species, are described, while the second enumerates 224. Although many of the fungi described in these works are such as are common to all kinds of decaying vegetable matter, and many others are doubtless only secondary forms of which the perfect state is unknown, there yet remains a goodly number that are directly or indirectly injurious to the vines which they infest. Of these, very few are known excepting to the mycologist. It is only those that have made themselves felt through their widespread and devastating effects that have received popular recognition. There are but four that can claim such prominence in this country. They are the Downy Mildew (*Peronospora viticola*, De By.); the Powdery Mildew (*Uncinula spiralis*, B. & C.); the Black-rot (*Physalospora Bidwellii*, Sac.); and Anthracnose (*Sphaceloma ampelinum*, De By.). These, together with one or two others of less importance, will be here treated.

I.—THE DOWNY MILDEW.

(*Peronospora viticola*, De By.)

The Downy Mildew is common to both the wild and cultivated grapes of this country, and from the former it doubtless was conveyed to the latter in the earliest days of American grape culture. In all the region east of the Mississippi, particularly in the Central and Middle Atlantic States, it has long been known as a serious pest. It is now reported to be in California, where the loss it occasions in some localities is variously estimated at from 10 to 50 per cent. In New England and along the northern tier of States, although of frequent occurrence, its action is comparatively insignificant.

In one respect Downy Mildew may be deemed a more serious enemy to viticulture than either of those to be described, as by its action on the leaves it affects the nutrition of the vine, weakening its vitality

* Dr. Rumueldo Pirotta: Funghi Parassiti dei Vitigni, Milan, 1877. Baron Felix von Thümen: Die Pilze des Weinstockes, Wien, 1878.

and eventually destroying it. This action upon the leaves interferes with the development of woody tissue in the growing shoots and prevents the ripening of the fruit, and the wine produced will be inferior both in quantity and quality.

There is no fungus disease of cultivated plants that has received more general attention by the horticulturist, nor one that has been more carefully studied by scientific observers, than the mildew under consideration, so that there are few points in its natural history not now thoroughly understood.

It was first collected in 1834 by Schweinitz, who erroneously referred it to *Botrytis canna* of Link. In 1848 it was named *Botrytis viticola* by Berkeley and Curtis, and was distributed, without description, by Ravenel in the fifth volume of his *Fungi Caroliniani*. It was not until 1863 that the fungus was referred to its proper genus and a full description given of it by De Bary in the *Annales des Sciences Naturelles* (serie 4, tome XX, p. 125). In 1876, in the *Bulletin of the Bussey Institution*, appeared Professor Farlow's very excellent paper on *The American Grapevine Mildew*. In the same journal (p. 427) and in the *Botanical Gazette* (vol. VIII, p. 309) Professor Farlow has published full botanical descriptions of the fungus. The most famous memoir, however, on this subject is that of M. Maxime Cornu, *Le Peronospora des Vignes*, published in Paris in 1882.

A great deal has been published in our agricultural and horticultural journals about the Downy Mildew, or *Peronospora*, of the vine, and much information, often of sound, practical value, has been disseminated in this way among the people respecting this pest; but for all that has been written it does not appear that any certainly efficacious remedy for the disease has been discovered in this country.

EXTERNAL CHARACTERS.

The Downy Mildew is a true parasite, closely allied to the fungus of the potato rot, and, through its action on the vine, produces changes that are quite characteristic. It attacks all the green portions—the leaves, young shoots, and berries—and in seasons favorable to its development causes not only a loss of the present crop, but often so diminishes the vigor of the vine as to seriously affect its future productiveness.

The vegetative portion of the fungus, the mycelium, traverses the tissues of the affected plant, going between the living cells and from them deriving its nourishment by the aid of little suckers. Threads from this mycelium, passing into the air without, through the stomata, branch and fructify and form the more or less conspicuous white patches that are familiarly referred to as the "Mildew," or the "Downy Mildew."

In the latitude of Washington this mildew appears about the middle of June, if sufficient heat and moisture prevail, and continues, with vary-

ing intensity, until the season of frosts. Pale green or yellowish spots of irregular size and outline appear upon the upper side of the leaves as the first manifestation of the disease. Corresponding points on the lower surface soon exhibit the outside development—the spore-bearing filaments of the fungus—in the form of white patches that are very conspicuous on the smooth-leaved varieties of grapes. As the disease progresses, the yellowish spots of the upper surface assume a brownish hue, which gradually becomes more intense, finally having all the characters of completely dried and dead tissue. These spots may be quite small; late in the season the older leaves attacked are often covered all over with minute brown spots, which are usually sharply defined, being limited by the nerves in the leaf; again they may be so large as to nearly cover the whole surface, in which case the destruction of the leaf is quickly accomplished. Under the final action of the fungus the leaf becomes thoroughly dried and shriveled as if burned, and the tissues are particularly brittle. It very rarely occurs that the mildew itself appears on the upper surface of the leaf. In severe cases the growth of the fungus extends to the young shoots, and, although the conidia-bearing filaments do not appear excepting upon the youngest and most tender of these, the action of the mycelium checks their further development, and finally the tissues are killed. The effect upon the shoots is often to produce dark-colored, slightly depressed markings as a consequence of the sinking away of the tissues beneath. These markings are quite distinct from the deep and lacerated lesions of Anthracnose.

It has been stated that the mildew only attacks the berries when they are quite young, and, so far as observed by the writer, this is true. The affected berries rarely attain more than one-fourth their full size, often remaining no larger than small peas; they soon turn brown or, when the fungus fruits upon them, gray in color. There is thus produced a kind of "rot" which is popularly named "brown rot" or "gray rot." From statements made by Prof. William Trelease* it appears that the mildew affects berries in advanced stages of their growth. In the fall of 1884, Professor Trelease spent several days at Ithaca, Wis., in the examination of rotting grapes. He states that the greater number of the diseased berries in that vicinity were simply drying up and falling, with no external sign of insect attacks. These berries when cut open showed quite uniformly a discolored appearance before any trace of injury could be seen at the surface. As a rule, while most of the pulp remained unaffected, a zone of browned tissue could be seen running almost or quite around the fruit between the seeds and the skin. In sections of this diseased tissue he discovered mycelium, which was evidently that of some *Peronospora*, possessing the small, round haustoria, or suckers, of the mycelium which is found in grape leaves attacked by *Peronospora viticola*, De By. Sections of grapes containing this mycelium were placed in damp air, and in the course of a few days

* The Grape Rot. Trans. Wis. State Hort. Soc., XV, p. 195.

several of them produced a small quantity of the fruit characteristic of this *Peronospora*. It appears, therefore, that the most destructive form of the grape-rot in Wisconsin is a direct result of the growth, in the berries, of the fungus which causes the common leaf disease of the vine.

The berries of some of the varieties of grapes cultivated on the grounds of this Department have been during the present season (1886) badly infested by the *Peronospora*. A bunch thus attacked is shown in Plate II. The peduncle is swollen and distorted because of the mycelial growth within, and the fructiferous filaments whiten, here and there, the berries as well as the stalks supporting them. To the left are shown three healthy berries taken from the same vine at the same time, and by the comparison of these with those diseased by the *Peronospora* the severe effects of this fungus are very forcibly illustrated. The diseased berries in this case were brown and had a rotten appearance, although they were of nearly their original firmness and not at all shriveled.

BOTANICAL CHARACTERS OF THE DOWNY MILDEW.

The fungus named by De Bary, *Peronospora viticola*, has been shown by repeated inoculations to be the direct cause of the "Mildew," the external characters of which have been described above. This fungus consists of a mycelium or vegetative portion which grows within the more tender and living tissues of the vine, producing the changes constituting the so-called "disease." Upon this mycelium at different periods and in very unlike ways two sorts of reproductive bodies or spores are formed, one kind produced externally on short filaments and named conidia, the other developed by a special sexual process on the mycelium within the tissue of the host plant and termed oöspores. The first are produced in great numbers throughout the summer and serve for the immediate propagation of the fungus, effecting its rapid distribution; the second are formed later and do not germinate until the following season. The former are often called "summer spores" in distinction from the latter, which have been named the "winter spores."

The mycelium.—The vegetative portion, or mycelium of the fungus, grows between the cells composing the tissues of the leaves, young grapes, and shoots, never through them, and the threads, or hyphæ, of which the mycelium is made up, branch most irregularly and vary greatly in diameter. In the more condensed tissues these threads are very fine, while in that which is less compact, and particularly in tissues having intercellular spaces of considerable size, the threads are coarser and are often curiously branched. These threads have no cross partitions, or septa, but are continuous throughout their whole length and are filled with a colorless, granular, and somewhat oily substance. At frequent intervals on these threads, as they push their way between the cells, minute lateral projections are formed that penetrate the adjacent cell-walls of the host from which they absorb the nourishment for

the support of the fungus, whence they have received the name of "suckers," or haustoria. These haustoria are nearly spherical, strongly contracted at the point of attachment with the hyphæ, their greatest diameter being rarely more than half that of the latter. The contents of the perforated cells quickly turns brown, ultimately effecting the outward changes already described.*

Just beneath the stomata, or breathing pores of the leaf, the hyphæ are particularly abundant and intricately entangled.† A number of branches from these masses of threads pass outward through the openings of the stomata, developing into the conidiophores or bearers of the conidia already referred to.

Conidiophores and conidia.—The slender filaments of the fungus that issue through the natural openings, the breathing pores, in the leaves, support upon their branched extremities numerous spores called conidia, and are hence named conidiophores or conidia bearers. Four to five or even as many as eight or nine of these conidiophores issue from each breathing pore, and it is because of their great abundance that the fungus becomes visible to the naked eye; the downy white patches of mold, so conspicuous on the under surface of the affected leaves, being wholly this growth. The length of these filaments averages about $\frac{1}{50}$ of an inch; their diameter is nearly uniform throughout, and their manner of branching, which is quite characteristic, is illustrated in figure 1. The ultimate points of the branches to which the conidia are attached are termed "sterigmata." A few hours of a single night is all the time required for the development of the conidiophores and conidia, but the mycelium may exist within the tissues of the leaves or other affected parts a long time before this outward development takes place. The conidiophores only appear under certain favorable atmospheric conditions, and, as these conditions may only occur at intervals of considerable length, we are in the habit of assuming that a new infection takes place each time. That vines previously free from the mildew may become affected at any time during the summer, there is no doubt, but the appearance of the mildew on the leaves may come from mycelium that arose from a much earlier infection.

FIG. 1.— Conidia-bearing filament of the Downy mildew. (After Farlow.)

The conidia are the reproductive bodies that are borne in great profusion on the ultimate branches of the coni-

* The mycelium is difficult to see, especially with the suckers adhering. It is most readily made out, perhaps, in fresh sections of the affected berries. To observe it in the leaves, fragments are detached from the mildewed parts and placed for an instant in strong acetic acid; they are then transferred to a concentrated solution of potassa, which is gradually warmed until it just reaches the boiling point. The fragments are now washed in alcohol, carefully dissected, and examined in glycerine.

† Farlow, Bull Bussey Inst., I, p. 418.

diophores. It has been estimated that from two to ten millions of these bodies may be produced on a single invaded vine, and as each conidium is capable of producing, should it fall upon "good ground," five or more new individuals, the reproductive power of the fungus passes our comprehension.

In shape the conidia are generally ovoid, the smaller end being at the point of attachment, their longest diameter being from $\frac{6}{10.000}$ to $\frac{9}{10.000}$ of an inch. They are very thin-walled, and are filled with a colorless, nearly transparent, granular fluid. Their formation takes place with great rapidity, and when mature they are most easily detached from their supports. In respect to the germination of these bodies I quote the following from Dr. Farlow's paper on *The American Grape-vine Mildew*:*

The germination of the conidia was studied by us in the beginning of October, when the fungus was in its prime. Leaves affected with the fungus were gathered in the afternoon, and allowed to remain under a moistened bell glass during the night. In the morning, parts of the leaves where fresh conidia had grown during the night were cut out, and the conidia shaken into watch-glasses, or onto glass slides containing a few drops of water. In order to test the conditions of germination, some of the bell glasses were placed in a light room, and others kept in the dark, and sowings were made at different hours of the day. The result was uniformly the same, whether the conidia were in the dark or light. Experiments in direct sunlight were, however, unsuccessful, as the sun's rays heated the water to such an extent as to cause rapid evaporation of the necessarily small amount of water used. With relation to the time of day at which the sowing was made, germination took place in all cases; but the conidia sown in the morning generally germinated somewhat more quickly and more abundantly than those sown in the afternoon. This might have been partly owing to the fact that the conidia sown in the morning were in better condition, the result of a growth of fourteen or fifteen hours, while those sown in the afternoon were the conidia produced during only four or five hours of the forenoon. It was not possible to keep the conidia which were produced in the night, until the afternoon, as they generally fell from their attachments in the morning, and began to germinate. In all cases, the germination took place with a surprising regularity.

At the end of an hour the conidia were slightly swollen, and their contents had begun to segment, * * * each segment having a light-colored nucleus. At the expiration of an hour and a quarter the segments had resolved themselves into a number of oval bodies, which collected at the distal end of the conidia, and which before long succeeded in rupturing the cell-wall and making their escape from the mother-cell. They passed out rather slowly, usually one at a time, and paused for a moment in front of the opening, where they remained as if not yet quite free from one another. In a short time each segment began to extricate itself from the common mass, moved more and more actively, and finally darted off with great rapidity a full-fledged zoöspore,† furnished with two cilia. The number of zoöspores produced in a conidium is very variable. The most frequent number is five or six. Sometimes there are not more than three, and we counted in one case seventeen.‡ * * *

The zoöspores move about for from fifteen to twenty minutes, the motion growing gradually slower. At the end of that time they come to rest, the cilia drop off, they

* Bull. Bussey Inst., I., p. 419.

† Locomotive spores, or spores possessing an animal-like activity.

‡ See figure 2.

assume a spherical shape, and in about a quarter of an hour an outgrowth appears on one side, which develops rapidly into the mycelium of a new plant.

FIG. 2.—Different stages in the germination of a conidium of *Peronospora viticola*, brought in at 8:45 A. M., October 9, 1885, and sown at once in water at about 69° F.

Four of the seventeen active zoöspores remained imprisoned and ceased to move at the end of 20 minutes. The others escaped quickly and swam away at once. The segmentation had already taken place, and, on account of rapid motion, the cilia could not be seen. (From notes and sketches by Erwin F. Smith.)

The manner of germination thus described by Dr. Farlow, *i. e.*, by zoöspores, is that which usually takes place. Under exceptional circumstances other forms of germination have been noted. In Plate IV, figure 7, the entire contents of the conidium is seen emerging *en masse*. This mass soon takes a definite shape, as shown in figure 8, and begins pushing out a germ-thread, figure 9. This form of germination was observed in artificial cultures in water at a temperature below 20° C.*

In figure 10 of the same plate, a third, and undoubtedly very rare, form of germination is illustrated. In this case a germ-tube is sent out directly from the conidium itself.

The germination by zoöspores is the most common, and perhaps we might say the normal habit of the *Peronospora* of the vine; and experience in cultures leads us to believe that no form of germination will take place except in the presence of water. A damp atmosphere is insufficient; there must be the actual presence of water, in the form of drops of rain or dew, to effect the formation of the zoöspores. The rapidity with which one of the conidia will germinate has been noted. If a mature conidium falls upon a drop of water on a grape leaf, within an hour or two the zoöspores will have already escaped and commenced the formation of their germinal threads. These threads doubtless pierce the epidermis, and the mycelium which is now developed insinuates itself between the tissues within. Temperature exercises a considerable influence over the germination of the conidia, that which is most favorable being between 25° and 35° C. At lower temperatures germination takes place more slowly; but the temperature may be reduced to zero without destroying the vitality of the conidia. Exactly how long these bodies will retain their vitality in a moist atmosphere

* Viala, Les Mild. d. Vignes, p. 39.

has never been determined, but it is known that dry air, particularly a dry wind, is destructive to them. Experiments have shown that in a dry atmosphere the conidia contract in a very short time, and shrivel up or burst and lose their contents.

In order to study the propagation of the mildew, Dr. Farlow placed leaves from different varieties of grape under moistened bell glasses and sowed conidia upon them in different positions. He found that the quickest method of infection was secured by laying a healthy leaf upon one affected with the fungus. In some instances the mildew appeared on the healthy leaves at the end of the second day. It made no difference whether the upper or lower surface of the healthy leaf was brought in contact with the infected one, so far as the contagion was concerned.* Infection has also been accomplished by sowing the germinating zoöspores on healthy leaves, in from five to seven days, according to the variety experimented on.

The oöspores.—During the summer or season of growth the *Peronospora* expends its energies in the production of the conidia, and these, in consequence, have been familiarly named "summer spores." There is no probability that they retain their vitality through the winter, their office being the immediate dissemination and propagation of the fungus. To tide over the season of winter another spore-form is produced, which is furnished with thickened walls and is still further protected by being embedded within the tissues of the host plant. These are the result of a special sexual process, and are termed oöspores or egg-spores. Spores of this class have also been called "winter spores." As stated, these "winter spores" are formed within the tissues of the infested plant. They have been observed within the leaves, and this season I have seen them in berries strongly invaded by mildew. Their formation begins as a slight swelling at the ends of the branches of the mycelium. This swelling finally attains a diameter of about $\frac{1}{8,470}$ of an inch, assumes a spherical shape, and the cell-wall covering it becomes thickened and pale yellow in color. At one side, arising from the branch that bears the oögonium or sack in which the oöspore is developed, another and smaller body is formed, which is termed the antheridium, and the former is only perfected when the contents of the latter is emptied into it. The antheridium, without detaching itself from its support, comes into close contact with the oögonium at an early period, and, later on, by a special mechanism, the granular protoplasmic contents of the former is conveyed to the latter, by which means the oöspore is fertilized.

The germination of the winter spore has never been satisfactorily determined†; but, however it may take place, it probably does not occur until the spring or early summer following its formation. There can

*Farlow, Bull. Bussey Inst., I, p. 422.

†Prillieux, in Bull. Soc. Bot., 1883, p. 228, quoted by Viala, l. c., p. 47, states that he has seen the oöspores pushing out a germ-tube, which branched and developed into a tree-like conidiophore.

be no doubt that it is through the germination of these bodies that the annual recurrence of the mildew is effected, for there is no other known way by which the fungus can be carried over from one season to another; hence the manifest importance of employing every means for destruction of these winter spores. They are naturally protected from all exigencies of climate, and they have been known to pass through the stomachs of domestic animals without apparent injury.

CONDITIONS WHICH FAVOR THE DEVELOPMENT OF THE DOWNY MILDEW.

The two conditions necessary for the development of the mildew are heat and moisture. Frequent showers or heavy dews or fogs, followed by hot sultry days, is the kind of weather which favors the development of this as well as most other injurious fungi. A vine so sheltered as to prevent the deposition of rain or dew upon its foliage in the form of drops will escape the mildew, although surrounded by vines invaded with the disease. Practical advantage has been taken of this fact, and the mildew avoided, by placing a board or other covering over the trellises, in the manner described by Mr. William Saunders, Horticulturist of the Department, in the United States Agricultural Report for 1861.

REMEDIES.

Our object in studying the nature and habits—the life history—of the injurious fungi is to discover some means by which we may destroy them, or at least check their development so as to reduce the amount of damage they would otherwise inflict upon our cultivated crops. If we find ourselves unable to combat a fungus in its actively injurious stage, we may, by careful investigations, discover some period in its development when its destruction may be effected with comparative ease. We know that the vegetative portion—the mycelium—of the Downy Mildew lies buried within the tissues of the host, and, although we may prevent the formation of the conidia or even destroy the conidiophores, any application that will destroy the mycelial growth within the affected parts would destroy these parts as well. In the case of this fungus preventive measures, rather than curative, must be sought. The great desideratum is a substance which, applied to the vines and foliage in season, will prevent the germination of the conidia or summer spores that may fall upon them. Hopes are entertained that such a substance has been found in a compound of sulphate of copper (bluestone) and lime. The following account of the preparation and application of this mixture is extracted from a paper by M. Foëx on "Practical Treatments for the Prevention of Mildew," published in *La Vigne Américaine et la Viticulture en Europe*, June, 1886:

I.—The Copper Mixture of Gironde.

(*a*) *Description of the process.*—A process which was discovered recently in Gironde gave in 1885 the most satisfactory results. It consists in spraying the vines, during

their growth, with a mixture of sulphate of copper and lime. This is prepared in the following manner: On the one hand, 6 to 8 kilograms* of sulphate of copper are dissolved in 100 liters† of cold water; on the other hand, 15 kilograms of quicklime are slaked in 30 liters of water. When the sulphate of copper is completely dissolved, and the lime has formed a homogeneous mixture, the latter is poured into the copper solution, the mixture being stirred meanwhile. We thus obtain, if the sulphate of copper is pure, a clear blue precipitate, which settles to the bottom of the vessel in which the operation is carried on. This substance should be stirred up at the time of using, in order to put it in suspension in the water.

(*b*) *Action of the remedy.*—The action of the remedy, which we have just described, is due to the copper which it contains. The presence of this metal, even in a very minute quantity, in drops of dew or rain on the upper surface of the leaves, prevents the germination of the spores of the conidia which may have been brought there by the wind. Thus forestalled, the disease cannot establish itself upon the leaves.

(*c*) *Mode of application of the remedy.*—The copper mixture should be distributed by sprinkling in little drops on the upper surface of the leaves. Two or three spots thus produced suffice to completely preserve a leaf, and they become sufficiently adherent and coherent, as soon as they have dried, to remain until the leaves fall.

The sprinklings were made in Gironde, in 1885, with a simple broom of heath, which was plunged into a bucket or watering-pot containing the mixture. This plan of operating gives satisfaction, so far as the distribution of the substance is concerned, but it has the inconvenience of being somewhat slow, and it requires much hand labor; therefore apparatuses have been devised which permit more rapid operation at a less expense of muscle. The one which gave the best results at the trial held in Montpellier, in February, 1886, was that of Mr. Delord, 9 rue St.-Gilles, Nîmes.

(*d*) *Time when the treatment should be made.*—The salts of copper having the effect, as we have seen, of preventing the disease from becoming established, their use should be preventive. The vines should, therefore, be treated before May 15, at which date the *Peronospora* has sometimes made its appearance in certain places in the department of Hérault. In operating at so early a date only a small portion of the leaves can be reached, the greater number developing between this period and the 1st of June; in practice, therefore, it is better probably to sacrifice, if need be, some of the first leaves, and make the treatment only when the vegetation has reached a sufficient development, say, in Hérault, from the 1st to the 15th of June.

Further remarks upon the value of sulphate of copper and other remedies against the *Peronospora* will be found in Appendix C.

In Italy the use of lime alone in combating the Downy Mildew appears, from the following notice, published in the *Bollettino di Notizie Agrarie*, September, 1885, to be valuable:

In a communication received from the school of viticulture and œnology of Conegliano, are stated the results obtained during the past year, by the various methods proposed to combat the *Peronospora*, many agriculturists in that locality having applied these remedies from the end of May to the beginning of June. Such applications were repeated by the most diligent among them at intervals of about twenty days, and principally after rain.

The months of June and most of July passed without there being noticed any trace of the malady, the drought and heat which then prevailed being conditions unfavorable to the development of the malady.

With the rains at the beginning of August, appeared the first signs of the *Peronospora*, at first in the provinces nearest to the sea, and thence to the hilly regions of the interior. One of the regions the most affected is that situated to the south of Conegliano, which is formed principally of the gravels and sands of the ancient alluviums

* 1 kilogram = 2.2 pounds. † 1 liter = 1.76 pints.

of the river Paive, and it was just here that were noticed the great differences between the various methods of treatment adopted.

The vines treated with the "milk of lime" remain green and enjoy perfect immunity from the *Peronospora*, even when they are in close proximity with those badly damaged, or when the branches are in close contact, which happens commonly enough, owing to the local custom, which consists in training or pulling the branches in the same direction.

We append below the conclusion of the report transmitted by the director of the school of Conegliano, resulting from a visit made by himself and his assistants to the farm of the brothers Bellussi:

"1st. On the branches which were treated once only during the present year, the preservation of the leaves is already decidedly noticeable in comparison with the vines not treated. Upon the vines on which the fungus had already spread, the part affected is found in a state of atrophy, the spores dead, while the rest of the vine is perfectly well preserved by the action of the lime.

"2d. In the vines upon which the treatment was applied early in May, the preservation of the leaves may be said to be perfect. They have attained a greater development than those suffering from the *Peronospora*, and their excellent state of nutrition is otherwise attested by the reddening stems of the fruit. While the latter is not very abundant it is sufficiently well nourished, and the wood is well developed.

"3d. On the vines which, besides being treated at different times during the year, received an application of the 'milk of lime' before the end of the previous autumn, the leaves are found in perfect condition, the fruit more abundant, and the wood better developed than in the preceding case, which is due to the fact that the application of the remedy during the preceding autumn permitted the better nutrition of the various parts which prepared the fruit and the wood for the coming season."

Finally, it results that, whenever the leaves are completely covered with the lime, either from above or below, they are perfectly well preserved, and the nutritive process in the plant is permitted to go on regularly.

The use of sulphate of iron as a remedy against the mildew has proved of value in the hands of some, and, if it should prove generally effective, it has the advantage of being much less expensive than the sulphate of copper. Dr. John Strentzel, of Martinez, Cal., in a letter addressed to the Commissioner of Agriculture, under the date of June 28, 1886, says:

I have been using for years solutions of sulphates of copper and iron to destroy parasitic fungi on vines and pear trees, also to kill red spiders on almonds. I have found the sulphate of iron more acrid, minute crystals corroding the vegetable fiber or blackening and scorching the parasitic growth; no such visible effect was produced by the application of the copper salt.

The poisonous effects of copper salts are known, and any particles adhering to the fruits are dangerous to health, and in distributing it over the foliage, particles would lodge on the green berries. I hold that the remedies against the *Peronospora* and allied mildews on the vine should be used to destroy the germs of the fungi, and ought to be applied when the vine is in a dormant state—the whole plant being liberally washed.

The mixture I use consists of 2 pounds of sulphate of iron to 1 gallon of water, dissolved, and add 3 pounds of lime and 1 pound of sulphur, the lime being slaked in hot salt brine to a consistency of thick whitewash. The chemical affinity of the ingredients favors the formation of chloride of iron, which is an effective fungicide.

All the old cuttings and leaves should be carefully collected and buried.

If, in addition to the employment of these remedies, a thorough system of what may be termed disinfection be followed, the probabilities are that the mildew would do little damage, even in seasons most fav-

orable to its development. The disinfection should be such as would destroy all the fungus germs that may be lying dormant within or upon the tissues of the vines that have been affected. To accomplish this, all the fallen leaves and berries, and the trimmings from the vines, should be raked together, removed from the vineyard, and burned; then, just before the buds begin to swell in early spring, the naked vines should be thoroughly washed in a strong (50 per cent.) solution of sulphate of iron. This washing may be done by dipping into the solution, which may be carried through the vineyard in any convenient vessel, a large wagon-sponge attached to the end of a mop-handle, and applying this directly to the vines. This application should be made in damp weather, so as to avoid a too rapid evaporation of the solution, which might result in injury to the plants treated. Such a bath as this is deemed an effective remedy against Anthracnose, and its action is considered as being in every way beneficial by those who have applied it. Mr. Jacob Schram, of Saint Helena, Cal., to whom I am indebted for a part of the statements here made, relative to the use of sulphate of iron, claims that the quantity of solution which necessarily falls upon the ground in making the application, as described above, has value as a fertilizer.

One method of avoiding the mildew, not yet alluded to, is that of selecting those varieties for cultivation which possess, from some unexplained reason, a power of resisting the attacks of the fungus. It is well known to grape-growers that some varieties are more "susceptible" to the attacks of fungus diseases than others; yet the evidence on this subject afforded by the replies to the circular of inquiries is conflicting, and it is very doubtful if, in seasons favorable to the development of the mildew, there are any varieties wholly exempt from the ravages of the disease.

I have compared the tables of Mr. Munson and of Bush, Meisner & Son, naming the varieties free from or liable to the attacks of mildew and other fungi, and I find such a disagreement between these and between the reports from vineyardists received at this Department, that I am led to consider the publication of any list of this character more likely to do harm than good, as being misleading.

II.—THE POWDERY MILDEW.

(*Uncinula spiralis*, B. and C.)

Like the Downy Mildew, the Powdery Mildew of the vine is a native of this country, and attacks the foliage, young shoots, and berries of both the wild and cultivated varieties of the grape, showing a decided preference to those of the Vinifera class. Here the resemblance ceases, however, for the *Uncinula* is a fungus of very different habit of growth from the *Peronospora*, and belongs to an entirely distinct group of para-

sites—a group embracing what are familiarly referred to as the White Mildews or Blights, of which the common Grass Mildew (*Erysiphe graminis*), the Lilac Mildew (*Microsphœria Friesii*), and the too well known Mildew of the Hop-vine are examples. The diversity extends even to the climatic conditions favoring the growth of these two fungi, for, while a liberal supply of moisture is necessary to the full development of the *Peronospora*, the *Uncinula* likes a comparatively dry atmosphere, and always occasions most injury during seasons of protracted drought. On account of this fact the Powdery Mildew has a wider geographical range, having extended into the drier regions of the West and along the Pacific coast into regions where the *Peronospora* has been unable to gain a foothold. It has long been known as a serious pest in California, and it is in these drier sections of the country that it has done the most damage, for, although it is nowhere entirely absent in the region east of the Mississippi, it effects, in the average season, comparatively little injury in the open vineyard—at least the injury is slight as compared with that wrought by the Downy Mildew.

In the grapery, carelessness in the matter of ventilation is very likely to bring on an attack of the mildew. It may be that a cold draft of air, or a sudden change of temperature, lowers the vitality and consequent resisting power of the vine—it "catches cold," one may say—and the mildew comes upon it. It is far more likely, however, that the changes effected in temperature, &c., by the leaving open of a window, were just such as to favor the germination of the fungus spores, already on the vine or wafted in through the ventilator, than that the presence of the mildew should be due to any diminution in the vital forces or vigor of the vine. Certain it is that where there are no spores of the fungus to germinate, there will be no mildew, whatever other conditions may prevail. That some varieties of grapes are more "susceptible" to the attacks of the Powdery Mildew than others everybody knows, but this does not warrant us in assuming that such varieties have a lower vitality than others. The preference lies on the part of the fungus, and may result from finding in juices of some varieties a more acceptable and nourishing food than in others. All soils will not produce the same varieties of plants equally well, nor can we suppose that all grape leaves—the "soil" upon which the fungus vegetates—will nourish equally well the *Uncinula*. There are also causes of a mechanical nature that may operate in the choice by the fungus of some varieties over others. The delicate suckers formed by the germ-tubes of the conidia and ascospores may find the epidermis on the leaves of some too thick or hard for them to easily penetrate. That a vine well nourished and in full vigor of growth is less open to the attacks of fungus parasites than one poorly fed or badly managed, there can be no question, but in seasons favorable to the development of the Mildews or the Black-rot, the best kept and most vigorous vines are liable to suffer from their ravages.

This season I have observed it in all its phases of development, both upon vines in the open air and upon those cultivated under glass here at the Department. Upon the foreign varieties in the grapery it was most abundant and its injurious effects most apparent.

The early history of this fungus is obscure, but as it abounds on the wild grapes of the country, it may be assumed to have always been present, to a greater or less extent, in the vineyards since the earliest days of American grape culture. It has frequently been discussed in our agricultural and horticultural journals for many years past, under the name of "*Oïdium Tuckeri*," or simply "*Oïdium*," it being supposed that our fungus was the same as the European vine mildew of that name, a matter to which I will refer later on. In the Patent Office Report (Agriculture) for 1853, p. 313, there appears a brief account of this fungus, and the employment of sulphur, both in a dry and liquid form, is recommended as a remedy. A more extended account appears in the same report for 1854. In this paper, which is written by Mr. J. F. Allen, of Massachusetts, a solution of lime and sulphur, the preparation of which is described, is recommended as a remedy against the mildew in question. In regard to its botanical history, it may be stated that the original specimens upon which the species *Uncinula spiralis* was founded were collected in 1851, in Pennsylvania, on *Vitis Labrusca*, and in 1856, in Massachusetts, on cultivated grape-vines.* Some recent authors have adopted the name *Uncinula Americana* of Howe for this fungus, but without sufficient reason, as will appear from the following communication from Dr. W. G. Farlow, in answer to inquiries made by me:

The fungus was first named and figured by Berkeley in his *Outlines of British Fungology*. It was then mentioned by name in Sprague's paper in the *Proceedings of the Boston Natural History Society*. Then came Howe's name, *Uncinula Americana*, which was never published by Howe. He sent round to a few people a strip of paper with a printed description, but that is in no sense a publication. It cannot be found in the market in any book, published exsiccatæ, or other form of recognized publication. In the *Erysiphei of the United States*, in *Journal of Botany*, Howe's description is quoted publicly for the first time, but with the qualification that it is not apparently different from *U. spiralis*, B. and C. The figure and name actually first given in Berkeley's *Outlines* have more claim to be recognized than the printed slip of Howe, which was merely a private memorandum.

The term "Powdery Grape-vine Mildew" was first applied to this fungus by Prof. C. V. Riley,† and as it is descriptive, and at the same time clearly distinguishes this mildew from *Peronospora viticola*, to which the same author has applied the name of "Downy Mildew," it has been employed here, with the hope that it may become generally adopted by those who prefer English to Latin names.

There are fewer difficulties in the way of gaining a complete knowledge of the natural history of the species of the group of fungi to which

* Farlow, Bulletin Bussey Institution, I, p. 423.

† Proc. Amer. Pom. Soc., Session of 1885, p. 49.

our Powdery Mildew belongs, the *Erysiphei*, than in almost any other of the class of *Ascomycetes*, and consequently their nature and habits have come to be very well known. The most complete account of the *Uncinula* described in this report is that given by Prof. W. G. Farlow in the *Bulletin of the Bussey Institution*, Vol. II, p. 109, illustrated by a plate of excellent figures.

EXTERNAL CHARACTERS OR GENERAL APPEARANCE OF THE POWDERY MILDEW.

The Powdery Mildew makes its appearance usually during the early days of June, and continues its development late into the autumn. Its entire growth is upon the outside of the invaded plant, no portion, excepting the minute suckers, or haustoria, which are said to penetrate the epidermal cells, ever entering within its tissues. It appears in dull, grayish-white patches, most conspicuous on the upper surface of the leaves, and when growing thickly on the young shoots or berries its mycelium imparts to these organs a similar hue. It never has the bright, lustrous, or frosty appearance that characterizes the Downy Mildew, and the livid brown or seemingly scorched blotches on the leaves that the latter fungus occasions are wanting, although in thin-leaved varieties of foreign vines a discoloration takes place through the whole thickness of the leaf, visible at the points below the patches of fungus growth on the surface above. In a few instances I have seen the mycelial growth so dense upon the leaves as to give them the appearance of having been spattered and blotched with whitewash, the spots being a pure dead white. Below these spots, on the under surface, there were visible decided discolorations and a slight convexity or malformation, the lower layers of cells in the leaves having continued to grow, while the development of the cells near the upper surface was prevented by the action of the fungus. This mildew is also found on the lower surface of the leaves, but never to the same extent as upon the upper side, and as it is only in the latter part of the season that it has been observed there at all, its presence is doubtless due to an extension of growth from other parts, as from the petiole.

Upon the young and tender shoots the fungus is often particularly abundant, its action being to check their growth. Its presence on the older and half-ripened shoots is indicated by distinct but irregular brownish blotches in the epidermis. Sometimes the *Uncinula* appears during the season of bloom, and, coming on the newly expanded flowers, causes them to abort. Attacking very young berries, when these are no larger than shot or small peas, their growth is permanently checked. Cases have come under my observation where the *Peronospora*, the *Uncinula*, and the fungus of the Black-rot were all engaged in their work of destruction upon a single bunch of grapes. It is needless to say that the destruction was complete.

Upon the older berries the presence of the Powdery Mildew is made evident, before the mycelial threads have obtained sufficient growth to become conspicuous themselves, by the minute brownish spots produced by the action of the suckers on the epidermal cells. These spots eventually become confluent, the epidermis dies or is so affected that it will no longer expand with the growth of the berry and consequently bursts, first forming tiny then gaping tears, the result being the death and decay of the berry. Oftentimes the fungus spreads over only a small portion of the berry; this part ceases to grow and a much distorted or imperfectly formed fruit is the result. The distortions are often carried so far that the berries crack open, exposing the seeds. We sometimes find nearly full-grown berries completely overgrown with the mycelium of the *Uncinula*, so that the brown specks above mentioned, if present at all, are completely hid from view. These berries eventually become dry and shriveled, and finally drop off. The eating of berries diseased by the mildew is said to produce nausea and vomiting.*

BOTANICAL CHARACTERS.

The Powdery Mildew consists of a mycelial growth that rests wholly upon the surface of the parts of the vine supporting it, and the reproductive bodies or spores. The threads or hyphæ of the mycelium have a uniform diameter of about $\frac{1}{6,000}$ of an inch (varying from 3 to 5 μ), are much branched and interlaced, and are provided with frequent septa or cross-walls. Where this mycelium is applied directly to the epidermis of the supporting plant, there are developed at short intervals irregular protuberances or suckers, by which the fungus fastens itself to the host and through which it imbibes its nourishment.

REPRODUCTIVE BODIES.

If the fungus be examined early in the season, say in June or early in July, short branches will be seen arising from the threads at right angles, or nearly so, to the plane of their growth. These branches may be found as late as the latter part of October. Figure 3 was drawn from a sample found on mildewed berries in the grapery of the Department, October 27. The branches are divided into several oblong cells by cross-walls. The uppermost cell is slightly larger than that immediately below it, and is rounded at its upper extremity. If this terminal cell be watched, we will soon see its lower end becoming rounded like the upper, forming thus a stricture between it and the next cell below, from which it is soon completely separated and falls off. There is thus formed a spore or reproductive body, called in this case a conidium, which is capable of quickly germinating and producing a new fungus growth. The next cell of the branch quickly passes through the same changes noted in the first, and in this way a number of conidia are formed

* Patent Office Report (Agriculture), 1853.

in rapid succession.* Like the conidia of the *Peronospora*, those of the *Uncinula* serve for the immediate propagation and dissemination of the fungus, but dampness, or a moderate amount of humidity only, is sufficient for their germination. They do not require water condensed in the form of drops of rain or dew, as does the Downy Mildew, and they germinate by the immediate production of a germ-tube and not by zoöspores, as in the case of that fungus. The conidia are thin-walled, oblong cells, of the shape illustrated in the figure, and filled with a transparent granular matter. Their longest diameter is about $\frac{1}{1,000}$ of an inch. One of these bodies falling upon a grape-leaf will, under favorable conditions of temperature and humidity, push forth a short germ-tube, which first sends a haustorium or sucker into an epidermal cell and then grows into the threadlike branched mycelial formation (thallus), diffused over the surface.† By their multitude these threads now become visible to the unaided eye, and we have what has been familiarly termed "Mildew," "*Erysiphe*," "*Oïdium*," &c. The temperature at which the conidia of the Powdery Mildew germinate most freely is the same as that which most favors the germination of those of the *Peronospora*, but the range of temperature under which they will develop is apparently greater than for that fungus.

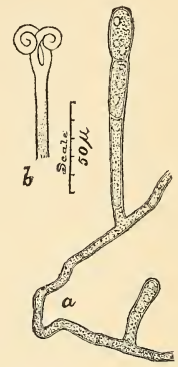

FIG. 3.—(*a*) A fragment of mycelium of the Powdery Mildew, with young and mature upright conidia bearing branches. (*b*) Terminal portion of one of the "appendages" which is branched at the apex.

When the mycelial growth has attained its full development a spore-formation of an entirely different character from that above described takes place. Perithecia, or what we may be allowed to term "fruits," are formed, within which spores are produced in a number of little sacs called asci. These "fruits" are especially abundant on the invaded organs of the vine during the months of September and October. To the naked eye they appear as minute dark brown or black points, thickly dotting the mildewed surface. The formation of these perithecia has been traced by De Bary in some other members of the *Erysiphei;* and the facts he has presented will apply to our *Uncinula*. He says:

The perithecia are engendered where two filaments cross each other. These swell slightly at this point, and each emits a process which imitates a nascent branch, and remains upright on the surface of the epidermis; the process developed from the inferior filament soon acquires an oval form and a diameter double that of the supporting filament; then it becomes isolated from it by a septum, and constitutes a distinct cell, which I qualify as an *oöcyst*. The appendage which proceeds from the superior filament always adheres intimately to this cell and elongates into a slender, cylindrical tube, which terminates in an obtuse manner at the summit of the same cell. At

* In Plate IV. figure 16, is shown a fragment of a mycelial thread with three of the conidia-bearing branches. Two separate conidia are shown at *a a*.

† De Bary, Verg. Morph. u. Biol. der Pilze Myct. u. Bact., p. 244.

its base it is also limited by a septum, and soon afterwards another septum appears a little below its extremity, at a point intimated beforehand by a slight strangulation. This new septum completes a terminal short and obtuse cell (the antheridium), which thus becomes borne on a narrow tube, like a sort of pedicle. Immediately after the formation of the antheridium new productions show themselves both around the oöcyst and within it. Underneath this cell and from the filament which bears it are seen to spring eight or nine tubes which join themselves to each other by their sides and to the pedicle of the antheridium, while they apply their inner face to the oöcyst, above which their extremities soon meet. Each of these tubes is then divided by means of transverse septa into two or three distinct utricles, and in this manner the multicellular wall of the perithecium springs into existence. During this time the oöcyst enlarges and divides, without its being possible to detect precisely how it happens, into a central cell, and an outer layer, which is ordinarily simple, of smaller utricles contiguous to the general enveloping wall. The central cell becomes the single theca proper to the species of *Erysiphe* of which we are speaking, and the layer which surrounds it constitutes the inner wall of the perithecium. The only changes which are afterwards to be observed are the considerable increase of the perithecium, by the fact of the development of all its component cells, the production of the radicular filaments or "appendages" which proceed from its outer wall, the brown tint which this assumes, and finally the formation of the spores in the theca.*

Instead of there being only one theca within the perithecium, as in the case of the species described above by De Bary, there are, in the *Uncinula* of the vine, four to eight. The external appearance of the perithecium of the Powdery Mildew is shown in Plate V, the figure being a greatly magnified drawing of the object, so as to clearly show its various parts. The dark central portion is the perithecium itself, which by pressure has been burst open on one side, and three of the thecæ, or asci, have been pushed out. Proceeding outward from the walls of the perithecium are a number of long slender filaments, termed appendages, that are rolled inwards at their extremities, forming a kind of hook; hence the Latin name *Uncinula*, from *uncus*, a hook. In their growth the perithecia are at first quite colorless, then pale yellow, and finally very dark brown or black. The appendages are clear and transparent at their extremities, but have a brownish color towards their bases. They are divided into several cells by transverse walls, and are sometimes, though rarely, branched or divided above (see fig. 3).

The asci, developed within the perithecium, are delicately-walled, transparent sacs that contain the ascospores or sporidia. These are oblong bodies, rather more rounded in outline than the conidia and somewhat smaller. They are the true winter spores of the fungus. Closely incased within the hard, compact walls of the perithecium they are well protected from injury and the severe weather of winter. In the spring the walls of the perithecium decay or crack open, allowing the sporidia to escape, and bring about a new infection of the vines. Doubtless a sufficient number of these fungus fruits remain adhering to the vines through the winter to bring about a recurrence of the disease as soon as the conditions favorable to the germination of the sporidia prevail.†

* From translation in Grevillea, I, pp. 152, 153.

† The dimensions of the various parts of *Uncinula spiralis* are: Diameter of mycelial threads, 3–5 micro-millimeters; height of conidia-bearing branches, 80–150 micro-

UNCINULA SPIRALIS AND OÏDIUM TUCKERI.

The fungus under discussion has long been referred to as the *Oïdium Tuckeri*, the name applied to the European vine mildew of like habit. Whether the European *Oïdium* is the same as our *Uncinula* or not is yet a matter of question, owing to the fact that the mature or fruiting form (the perithecia) of the first named has never been discovered, the conidial stage alone being known. De Bary has suggested that the European *Oïdium* is an importation from America, as it was not known on his side of the Atlantic prior to 1845, and that, although fruiting abundantly in its native country, it has so far failed to effect a complete development in regions foreign to it. In speaking of the developmen of the *Erysiphei*, De Bary says:*

Growth does not always proceed to the conclusion (*i. e.*, the formation of the perithecia); the fungus may rather form only conidia, and propagate itself by means of these through numberless generations. Most clearly established external causes lie at the bottom of this: climatic conditions on the one hand, lack on the other of the nourishing soil requisite to a full development; that is, the proper host plant. The finest example of this is the *Erysiphe* of the vine. Concerning its first appearance and spread in Europe, it can be accepted as certain that it was transported suddenly from some other flowering species introduced into our vineyards from abroad. *Most probably its immigration is from America.* In spite of its destructive spreading over the whole vine-growing portion of Europe, the most careful investigations in this country have nowhere led to the discovery of any indication of perithecia; the entire invasion takes place by means of the conidia, produced in great abundance, the form of which has procured the fungus the name of *Oïdium* (*O. Tuckeri*). The perithecia are probably found in North America on the native sorts of *Vitis*, and have been described as *E.* (*Uncinula*) *spiralis*, Berk. and Curtis, yet this not certain.

In a paper on *The Mildews of the Vine*,† Prof. C. V. Riley remarks that—

One of the most interesting facts in connection with this fungus is that only the conidial form, known as *Oïdium Tuckeri*, occurs or is so far known in Europe. There is some question as to the actual specific identity of *Oïdium Tuckeri* as found in Europe and the conidial stage of *Uncinula spiralis* as found in this country. The bulk of opinion is that they are identical. We have, in fact, in this case, one somewhat parallel to that of the grape-vine *Phylloxera*. The gall-making form of this insect upon the leaf is of very common occurrence and the form most easily observed in America; whereas in Europe the species very rarely produces the gall. Yet the historic evidence is conclusive as to the introduction from America, both of the *Phylloxera* and *Oïdium*, and to my mind they both furnish admirable illustrations of a change in an organism sufficiently marked that, without the historic evidence, the question of the exact specific identity of the parent and its transcontinental issue might well be raised. The interesting question, philosophically considered, is why, if the winter spore is necessary to the perpetuation of the *Uncinula* in America, the species can propagate for an indefinite period without it in Europe.

millimeters; size of conidia, 10–15 micro-millimeters by 25–30 micro-millimeters; diameter of perithecia, 80–120 micro-millimeters; diameter of appendages, about 7 micro-millimeters; length of appendages, 300–600 micro-millimeters; size of ascospores, 10–12 micro-millimeters by 20–25 micro-millimeters.

* Verg. Morph. u. Biol. der Pilze, etc., pp. 244-5.

† Proc. Am. Pom. Soc., Session of 1885, p. 50.

It may be that the "winter spores" of the *Oïdium* are developed in Europe on some other host plant or in some form the connection with which has escaped the notice of botanists. Rev. M. J. Berkeley, in the *Gardeners' Chronicle* for 1884, figures the *Uncinula spiralis* from specimens on leaves received from the United States, and he remarks that upon the same leaves he found an *Erysiphe*, probably *E. communis*, which attacks a great variety of plants, and he makes the assertion "that, after all, this may be the true result of *Oïdium Tuckeri*." Fuckel* refers the *Oïdium Tuckeri* to *Sphærotheca Castagnei*, the Hop-vine Mildew, but there is no evidence to sustain this view.

Although I do not know of any "historic evidence" to prove that the *Oïdium* of Europe is an emigrant from this country, there is some reason for such a supposition; and the fact that it has there never developed its perithecia or ascosporous form, is not the only example of such a change of habit among fungi.

REMEDIES.

As the Powdery Mildew is wholly a surface-growing fungus, it is exposed to the direct action of any fungicide that may be employed to destroy it. For this reason a curative remedy rather than a preventive is to be sought. Whether there are any remedies that will act as preventives is not known, but it is known that there are remedies which certainly destroy this mildew if properly applied. It is not necessary to enumerate all the materials which have been used with this object in view; it is sufficient to say that trials, more or less successful, have been made with many substances, and that these have all been discarded, excepting sulphur or a compound of sulphur and lime. Both the dry flowers of sulphur and sulphur and lime in solution have been recommended as remedies ever since this mildew began to attract the attention of the vineyardist. In the Patent Office Report (Agriculture) for 1853, page 313, occurs the statement that "sulphur applied to the vine, as well as to peach trees, with a little attention in the early stage of its appearance, will entirely subdue the blight." Mr. J. F. Allen, in the Patent Office Report for 1854, recommends the following wash for the mildew:

> Take one peck of lime, not slaked, and one pound of sulphur; put them in a barrel and pour hot water over them sufficient to slake the lime; pour on this three gallons of soft water, and stir the mixture well. In twenty-four hours it will have settled and become perfectly clear. This should be drawn off as clear as possible. Half a pint of this mixture added to three gallons of water will be sufficiently strong, and may be applied over the fruit and every part of the vine when the mildew first appears. The application can be repeated every few days if occasion requires. The first application I have found would kill the most of it [the mildew]; a second and a third is all that I have found necessary for the season.

This preparation is essentially what is popularly known as "liquid grison," "eau grison," or "polysulphure grison," which is prepared by

*Symb. Mycolog., p. 79.

boiling three pounds each of the flowers of sulphur and lime in six gallons of water until reduced to two gallons. When settled pour off the liquid and bottle it for use. One pint of this clear solution in twelve gallons of water is the strength recommended for use. The application of these fluid compounds is best accomplished by attaching to the hose of the pump used a cyclone nozzle of proper aperture. By this appliance any liquid solution may be diffused over all parts of the diseased vines in the form of a very fine mist-like spray.

Either of these preparations is an excellent and effective remedy against this form of mildew, but they are no more certain in their action than the flowers of sulphur alone, and the application of the latter has the advantage of being attended with less labor and cost.

Opinions differ as to the exact manner in which this substance acts on the fungus, but it appears that it is not necessary to bring the particles of sulphur into immediate contact with the spores and fungus threads to effect their destruction, for this may as well be accomplished by the fumes which the flowers of sulphur emit at elevated temperatures. The knowledge that heat favors the production of these fumes makes it obvious that the best time to make the sulphur application is when the thermometer stands the highest. The fumes are given off very rapidly when the temperature ranges between 75° and 95° F., the temperature most favorable to the development of the fungus. The higher the temperature the more abundant are these fumes, and, consequently, the more rapid will be the destruction of the parasite. In latitudes where the soil temperature reaches 110° to 120° during the day, it has been found that spreading the sulphur on the ground under the vines is sufficient to accomplish the destruction of the mildew, and a like result is obtained by dusting the sulphur over the hot-water pipes in the grapery, providing these be sufficiently heated.

It has been stated that when the temperature does not exceed 77° F. the effects of the sulphur on the mildew are apparent only after the lapse of seven days. If the sulphuring be delayed until the formation of the perithecia takes place it is not likely to do much good, for although it may destroy the mycelial threads, the ascospores are too well protected within their hard coverings to be injured by the application.

The time when the sulphur should be employed is in early summer, at the first appearance of the mildew, and the application is most effective when made on a warm, bright day after all dew has evaporated. However well this application may be made it is almost certain that some of the fungus threads and many of the conidia will escape destruction. From these, or from spores brought from other vineyards, a new infection may appear in from twenty to thirty days, when a second sulphuring should be made.

In districts particularly subject to this disease it is recommended that the vines be sulphured, first, when the young shoots are about 4 inches long; second, at the time of blossoming; third, some days before the

turning of the berries. In bad seasons the mildew may make its appearance between these periods, when, of course, additional sulphuring should be made. Particular emphasis is placed upon the sulphuring at the time of bloom, for the flowers are almost certain to be rendered sterile if attacked by the *Uncinula*, and every precaution should be taken to prevent, if possible, the development of the mildew at this time.

III.—BLACK-ROT.

(*Physalospora Bidwellii*, Sacc.)

There is no disease of the vine that has more seriously affected the interests of the viticulturist in this country than that which has come to be universally styled the "Black-rot." The losses arising from this malady in the regions where it prevails are usually greater than from all other causes combined, as a glance at the circular replies in Appendix A very clearly demonstrates.

Like the mildews already described, the Black-rot is a disease of American origin, and the practical grape-grower, at least of the Middle Atlantic and Central States, has long been familiar with its appearance and baleful effects. It is reported to have ravaged the vineyards in Southern Ohio in 1848, and in 1867 it is referred to as being a veritable scourge in several of the Western States. According to recent reports received at this Department, the Black-rot now prevails to an injurious extent, frequently causing the total destruction of the grape crop in many sections of Alabama, Georgia, Illinois, Indiana, Maryland, Mississippi, Missouri, North and South Carolina, New Jersey, Ohio, Pennsylvania, Tennessee, Virginia, and Kansas.

In 1861, Dr. George Engelmann clearly pointed out the characters of this rot, and described the fungus which produces it, in a paper communicated to the Saint Louis Academy of Sciences. It is now twenty-five years since the publication of this paper, wherein the fungus is first connected with the disease, and although a great deal has been written and published on the subject in later years, very little additional information has been acquired. The atmospheric conditions favoring the development of the disease had already been pointed out, and the fact that certain varieties were more subject to it than others had already been noted.

In 1885 the Black-rot was discovered for the first time in France, and early in the present year there appeared in the *Bulletin de la Société Centrale d'Agriculture du Département de l'Hérault*, a carefully prepared and well-illustrated memoir on this disease by Viala and Ravaz.

EXTERNAL CHARACTERS.

The Black-rot rarely attacks the berries of the grape before they are two-thirds grown; the disease more often manifests itself on berries of nearly full size. It is rare also that all the berries in a bunch are

affected, at least at the first infection; there are nearly always some few in each cluster that escape the disease.

In its first manifestations there usually appears upon one side of the berry a livid brown spot, which gradually increases in size until the entire grape is uniformly discolored, imparting to it the appearance of rottenness, although its original contour and firmness are retained. Even before the completion of this change it usually happens that the part first affected becomes darker in color, and minute, black pimples or pustules are developed, imparting a roughness to the surface. At the same point the berry now begins to lose its fullness, an irregular depression appears, which soon extends into a general withering of the berry, the pimples meanwhile having multiplied so rapidly as to cover its entire surface. The destruction of the berry is now complete; it is hard, dry, shriveled to one-half or one-fourth its original size, the folds of the skin being closely pressed upon the seeds and raised into strong, prominent, and irregular ridges. These last and the little pimples, which are easily seen with the naked eye, are characteristic of this form of rot. All stages of the disease are very well shown in Plate III, which is made from a photograph of a diseased bunch taken from the vineyard of the Department early in July, 1885.

The rotted berries remain firmly attached to their supports for a long time, sometimes even till the following spring.

The disease does not extend from one berry to another by contact nor through the tissues of the pedicels and common peduncle, but there is a distinct infection for every berry diseased.

The manifestations of the Black-rot do not always appear as detailed above, for not infrequently the first evidence of the disease is the sudden appearance of one or more circular, slightly depressed spots of a bluish-black color, in the center of which there soon appear a few of the little pimples or pustules above referred to. These spots increase in size, the pimples in number, and ere long the berry exhibits the black and shriveled appearance already described.

These changes are effected in from one to five days, varying with the atmospheric conditions.

Some authors assert that the same fungus which produces the rot in the berry also attacks the young shoots and leaves, but I am not yet convinced that this is so.

BOTANICAL CHARACTERS OF THE BLACK-ROT.*

(*Physalospora Bidwellii*, Sacc.)

The external characters of Black-rot are determined by the growth of the mycelium of *Phoma uvicola*, B. and C., or, if we assume the mature form to be correctly determined, *Physalospora Bidwellii*, Sacc. As soon

*Read before the Botanical Club of the American Association for the Advancement of Science, at Buffalo, N. Y., August, 1886.

as the berry exhibits any signs of the malady, a thin section through the discolored part will show, under the microscope, the mycelium or vegetative portion of the fungus. This will be found near the surface of the berry, and will be seen to consist of hyaline, colorless threads or hyphæ of very irregular diameter (1–4μ), much branched and provided with more or less frequent septa. The very young branches remind one by their shape of the haustoria of *Peronospora*, but their position in respect to the cells of the host and their subsequent development reveal their true character. The presence of the septa is alone sufficient to distinguish the mycelium of the *Phoma* or *Physalospora* from that of *Peronospora*.

The mycelium traverses the tissues both between and through the cells, and under its action the latter soon loss their turgescence and their contents turns brown; they gradually collapse and flatten, and the dried pulp remains only as a thin layer of tissue, in which the vegetative part of the fungus occupies a large part.* During the earlier stages of the disease the mycelium is most abundant near the surface of the berry, and here, at frequent points, just beneath the cuticle, it makes a condensed growth that results in the formation of the perithecia or conceptacles destined to contain the spores. At first colorless, the pseudo-parenchymatous tissue of these conceptacles soon becomes pale yellow, then brown, and finally black. The conceptacles themselves are ovoid or globular bodies, varying in size from 75μ to 140μ in diameter, and in their development they raise and finally burst through the cuticle, imparting to the surface of the berry a pimply or pustulous appearance. At the apex of the exposed part of each conceptacle there is a minute opening or osteolum, through which the spores escape at maturity.

The microscope reveals the fact that the conceptacles are of two sorts, pycnidia and spermagonia—names determined by the character of their contents; otherwise they do not differ except in size, the pycnidia being the larger.

Pycnidia.—A cross-section of a pycnidium shows a clear zone lining the cavity, consisting of very delicate tissue, that gives rise to the short and thin-walled threads, the *basidia*, upon which are borne the spores, in this case called *stylospores*, that completely fill the remaining portion of the cavity. These stylospores are one-celled, round or somewhat oblong, being in their longest diameter about 8μ. Under an amplification of 500 diameters the cell-wall is clearly discernible, the contents having a beaded appearance; or sometimes one or two nuclei in the otherwise clear contents are seen. These spores escape probably by the absorption of water through the osteolum or opening at the apex of the pycnidium. Under certain conditions they issue as a minute, worm-like thread, which is composed of vast numbers of spores glued or held together by a kind of mucilage (see figure 20, Plate IV.). These threads, which are more or less twisted, are easily seen with a

*Viala and Ravaz, *Mémoire sur une Nouvelle Maladie de la Vigne, le Black-rot*, p. 416.

pocket-lens. This manner of protrusion is probably not constant, but exists under certain favoring conditions.

The stylospores germinate freely in water within a space of three or four hours. They throw out a slender tube, which soon provides itself with septa, branches, and quickly develops into a mycelium in every way like that seen within the tissues of the berry. How long these stylospores may retain their germinative power is unknown, but it is not likely that they hold it through the winter season.

Spermagonia.—The spermagonia have exactly the appearance of the pycnidia, but are usually smaller; they are also far less numerous. Within the outer wall there is a clear zone, from which arise the very slender basidia that project radially towards the center of the cavity. The spores, or, as they are termed, the spermatia, having been supposed to have a fertilizing power, are borne upon the summit of the basidia, and when mature escape in vast numbers from the spermagonium through an opening at its apex. They are cylindrical obtuse at each end, 5–8μ long and about 0μ.7 in diameter. What may be the rôle of these spermatia in the economy of the fungus, is a matter of speculation. In speaking of the nature of these bodies in general in the order *Pyrenomycetes*, Cornu says they are true spores, since they germinate and give out filaments having all the appearance of mycelial threads. He regards them as very small conidia of a special form, borne upon particular arbuscles in protecting conceptacles. They do not in general germinate in pure water, and they have a rather slow development; their physiological rôle appears to be determined by their very small size and the circumstances which their germination requires.

It has been quite generally supposed that they constitute the male element in the process of reproduction, but there is no evidence to sustain this opinion. Their very small size and consequent lightness have suggested to the minds of some that their office is to more certainly effect the wide distribution of the fungus. It seems to have been conclusively shown that they are not the spores of a parasite on the *Phoma*.

The species of the genus *Phoma* are believed to represent merely one stage or condition of certain ascigerous fungi yet to be determined. Prof. W. G. Farlow has very carefully described and illustrated the various conditions of spore-bearing forms of the fungus that cause the Black-knot of the plum and cherry trees.

In this case there are shown pycnidia containing stylospores, spermagonia filled with spermatia, conidia produced externally on short stalks or conidiophores, and sporidia, which are spores formed in little sacs or asci within a perithecium. The last or ascigerous form is the mature or perfect state of the fungus. We have here four distinct varieties of supposed reproductive bodies—pycnidia, spermagonia, conidia, and sporidia. In the Black-rot we have seen the first two upon the same mycelium and even associated in the same stroma, so that there is no possible doubt of

their connection; and, reasoning from analogy, we would expect to find also the conidial and ascigerous forms.

Conidia.—I am confident that I have seen upon completely diseased berries gathered from the vine, but more particularly upon similarly diseased berries kept moist for a few days under a bell-jar, the conidiophores of the *Physalospora* bearing imperfectly developed conidia. They certainly appeared to be growing from the exposed portions of the pycnidia, but whether from these or from especially formed sclerotia I am not prepared to say.

Messrs. Viala and Ravaz state that berries diseased with Black-rot placed in the earth have developed sclerotia, and, maintained in the soil at a temperature of 18° to 20° C., these sclerotia have produced conidiiferous filaments. At Val Marie, on the 17th of December, they observed sclerotia upon berries destroyed by Black-rot and which had lain upon the ground for some time. These berries placed in a moist atmosphere at a temperature of 20° to 22° C. produced the same conidiiferous filaments.

Mr. Erwin F. Smith, who made a special study of the characters of the fungus of the Black-rot, at the laboratory of the University of Michigan, in the spring of 1886, discovered similar filaments with conidia attached (see Fig. 4). In his notes he says:

> These [the conidia] are usually borne on conidiophores arising from that part of the perithecium which bursts through the epidermis of the berry. I found them very often in this situation, but nowhere else on the berry, and was slowly forced to believe them a part of the *Phoma*, though I could not entirely satisfy myself.

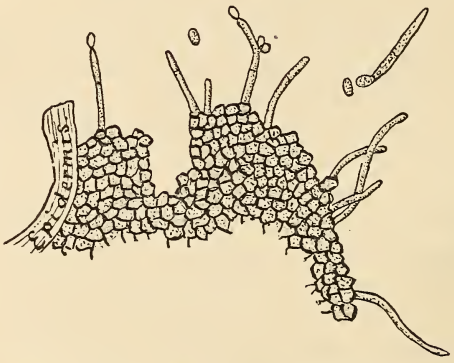

FIG. 4.—Conidia-bearing filaments growing from the condensed stroma of the fungus of the Black-rot. (From camera-lucida sketch.)

The conidia serve to propagate the fungus, and consequently the rot which it occasions. If their development be delayed until spring, as, perhaps, it often is, a knowledge of their existence is particularly important, for by them the disease may be perpetuated from year to year.

Sporidia.—The discovery of the mature or ascigerous form of the so-called *Phoma uvicola*, or what it seems reasonable now to believe to be such, is recorded by Mr. J. B. Ellis, of Newfield, N. J., in the *Bulletin of*

the Torrey Botanical Club for August, 1880 (Vol. VII, p. 90). Mr. Ellis says that in the early part of May, 1880, Dr. E. C. Bidwell, of Vineland, N. J., informed him that he had discovered the ascigerous form of the fungus to which *Phoma uvicola* belongs. The grapes on which the form in question was found had been diseased with the rot the season previous, and were still hanging dry and shriveled on the vines. By way of experiment, some of these berries were placed in water, where they were allowed to soak for three or four days. At the expiration of this time many of the perithecia (that before contained only *Phoma* spores) were now filled with well-developed asci containing immature sporidia. Following up this discovery, Mr. Ellis at once searched for similar developments in shriveled grapes from his own vicinity. His efforts were rewarded by finding some ascigerous perithecia, together with an abundance of *Phoma*, on grapes gathered from the ground, where they had probably lain through the winter.

Messrs. Viala and Ravaz did not succeed in finding nor were they able to induce the development of the ascosporous form; neither have my efforts to this end met with better success. Thanks to the kindness of Mr. Ellis, who has very generously supplied me with specimens of his own collecting, I have been enabled to study its appearance and illustrate it* (see figures 24–26, Plate IV).

The perithecia containing the asci are in all respects like those that inclose the stylospores, and they have every appearance of being developed from the same mycelium. The walls of the asci are very transparent, and it is difficult to determine their outline except they be separated and viewed singly. They are cylindrical or subclavate, abruptly contracted at the base, obtuse at the summit, straight or occasionally somewhat curved. Except for the sporidia they contain they are perfectly transparent. Each ascus contains eight sporidia.

Mr. Ellis named this fungus *Sphæria Bidwellii* in honor of its discoverer; by a more recent classification it becomes *Physalospora Bidwellii*, Sacc. If we are right in our conclusions, we see that it has four kinds of reproductive bodies: First, the stylospores, inclosed in conceptacles, together constituting the *Phoma uvicola* of authors; second, the spermatia, produced at the same time and enclosed in similar though smaller conceptacles; third, the conidia, externally developed on short conidiophores; and, fourth, the sporidia, which are formed in asci that are inclosed in a protecting perithecium. The stylospores, and possibly also the spermatia, are undoubtedly designed for the immediate propagation of the fungus. The conidia probably serve the same purpose, and by their tardy development may help to continue the fungus from year to year. The sporidia are, without doubt, the special reproductive bodies

* Mr. Smith, in his investigations above referred to, found the ascosporous form very frequent in the berries examined after May 10. He discovered the asci in all stages of development, from very small immature ones to perfect ones containing well-developed ascospores. *Mingled with the asci were the usual paraphyses.*

for the latter purpose. The mycelium within the diseased berries retains its vitality during the winter months, and through the agencies of warmth and moisture of spring and early summer the asci and sporidia are produced.

The germination of these sporidia has never been observed, but if by any system of culture they can be made to reproduce the *Phoma* of the Black-rot their real nature will no longer be a matter of doubt.

REMEDIES.

It is plainly evident, from the very nature of the fungus of the black rot, that it is a disease to be prevented rather than cured. By watchful care and diligence the malady may be held in check, but when the mycelium has once established itself within the tissue of the berries their destruction is certain. It is known that the fungus passes the winter in the diseased and withered berries of the previous season, and possibly also in the young shoots. Hence, by gathering and raking together in the autumn all the fallen berries and trimmings from the vine and burning them, just so much infectious material will be destroyed. The washing of the vines in early spring, before the buds have commenced to swell, with a strong solution of sulphate of iron, may assist in this work of prevention by destroying the disease germs. The only effective method yet discovered, however, is that of bagging the clusters of grapes when about half grown. By this means the spores of the fungus are prevented from gaining access to the fruit, or, if they succeed in this, their germination is prevented by the absence of condensed moisture, which is essential to its accomplishment.

More extended observations on this subject of prevention will be found in Appendices A and B.

IV.—ANTHRACNOSE.

(*Sphaceloma ampelinum*, De Bary.*)

Early last June samples of grapes were received by the Department from Mr. G. Wanner, of Walhalla, S. C., that exhibited a disease having characters wholly unlike those of either of the mildews of the grape or the Black-rot, excepting in the matter of damage inflicted, which appeared to be quite equal to that of the last named. The affected grapes were the Clinton and Elvira, and, so far as observed by Mr. Wanner, these were the only varieties attacked by the disease, but the loss in the case of the Elvira was complete, every cluster on the vines being

* The fungus here described and figured is certainly the *Glœosporium ampelophagum* of Saccardo, and although some authors treat this as a species distinct from *Sphaceloma ampelinum*, others consider them identical. The action of the two on the host plant is essentially the same and the technical differences upon which the separation has been based appear to be of small importance.

destroyed. A cluster of this variety, as received from Mr. W., is figured on Plate VI *a*.

Later, samples affected with the same malady were received from Minnesota, Michigan, Illinois, Delaware, and New Jersey. In every case the diseased berries were of light-colored varieties. Mr. A. W. Pearson, who communicated the specimens from New Jersey, wrote that he had observed this disease only on the Riparia family, on the Clinton and Elvira, and on his white seedling crossed between Riparia and Labrusca. He had never seen it on the Concord or Ives, nor on any of the Æstivalis class, and it was only in very wet seasons, like the present, that he had seen it at all. Mr. J. T. Lapham, writing from Clayton, Del., states that this disease, which he calls "dry rot," is mostly seen on the white grapes, such as the Niagara and Pocklington, "and a little also on the Hartford Prolific, which is a blue grape."

Serious and wide-spread as this disease now appears to be it seems not to have attracted the attention of grape-growers in this country before the present season, nor have any of our mycologists, who are always on the lookout for such things, observed it until within the past five or six years. Prof. T. J. Burrill, of Champaign, Ill., was the first to discover and record its actual presence in this country. He first observed it in Central Illinois in 1881,* and afterward in many other localities in that State; also in Indiana, near Indianapolis; in Michigan, at Lansing; and in Ohio, at Cleveland.

It is doubtless an importation from Europe, where it has been known to prevail, often to a very serious extent, for many years, and is there designated under various names, as "Charbon," "Brenner," "Schwarze Brenner," "Pech," &c., but the name now in general use is "Anthracnose," derived from the two Greek words "coal" and "disease."

In the *Proceedings of the American Pomological Society* (Session of 1879), Mr. Isadore Bush, of Missouri, in a paper on "Grape Rot," refers to this disease and gives an abstract of a treatise upon it by R. Goethe, a German investigator, wherein its external and minute characters are fully described. It is again described in the Proceedings of the same society, Session of 1885, by Prof. T. J. Burrill. In the *Bushburg Catalogue* (1883) this disease is clearly described by Dr. George Engelmann, who, however, had never observed it in this country. In a footnote to this description the authors of the catalogue state that it is now known to exist in America. The most recent and extended discussion of the subject, however, is that given by Viala in his *Maladies des Vignes*, in which all the different phases of the malady are clearly described and illustrated.

Anthracnose, like the Black-rot, is caused by a minute fungus, the habit of which, however, is radically different from the fungus of that disease, as are also the external changes which it induces. All the green parts of the vine are subject to its attacks from the beginning of

* Proc. Am. Pom. Soc., 1885, p. 47.

spring vegetation until the close of the growing season, and, when very abundant, the injury occasioned to the young shoots is quite as serious as its action on the fruit.

EXTERNAL CHARACTERS.

That the external characters of Anthracnose are determined by the growth of a special fungus has been demonstrated by repeated inoculations or sowings of the fungus spores upon healthy shoots and berries.

On the shoots.—There first appear minute brown spots, a little depressed in the middle, with a slightly-raised darker-colored rim or border. These spots soon increase in size, elongating in the direction of the striæ of the bark, the central portion becomes more evidently depressed and usually takes on a grayish hue. The bark is finally destroyed, and, in severe cases, the woody tissues beneath appear as if burned or corroded, so deeply sometimes as to reach the pith.

The appearance and action of the fungus on the leaves is similar to that upon the stems, and it is certainly very evident that where the diseased spots are numerous, and the action of the fungus proceeds without interruption, both shoots and leaves must succumb to the parasite. The intensity of the disease upon the shoots may cause the destruction of the young leaves, even when the latter are not directly attacked.

On the berries.—So far as my own observations are concerned, the severity of this disease has been especially manifest in its effects upon the fruit. In order to appreciate the full extent of the injury occasioned to the berry one has only to consult Plate VI, figure *a*, which is an exact representation of a bunch of Elvira grapes received from Mr. Wanner, of South Carolina, diseased with Anthracnose. The progressive stages of the malady are here fully illustrated, and the colorings have been very exactly reproduced. A little to the left of the center is a berry, showing the first external manifestation of the disease. There is a small spot, grayish in the center, where the cuticle of the berry has been destroyed, with a dark-brown border. Previous to the bursting or rupturing of the cuticle the entire spot is of a deep-brown color.

These spots enlarge, retaining a more or less regular, rounded outline, and between the light-colored central portion and the dark border line there is developed a well-defined band of bright vermilion. Finally, under the action of the disease, the berries begin to wither and dry up, leaving nothing, apparently, but the skin and the seeds. There is no browning of the tissues of the berry as in the case of the Black-rot, nor does the skin shrivel as in that disease, leaving prominent and very irregular ridges, but the circular spots first formed are easily seen and the colorings characteristic of the disease are retained. A berry may be attacked upon one side when it is not more than one-half grown; it then becomes irregular in shape, the diseased part making no further development, and it sometimes happens that this side cracks open, ex-

posing the seeds, which are gradually forced out by the unequal growth of the berry.

The fungus.—The fungus of Anthracnose was first described by De Bary in 1873, and named by him *Sphaceloma ampelinum.* It doubtless belongs to the same class as that which includes the fungus of the Black-rot, but the several stages of its development have never been satisfactorily made out. We only know the fungus in its active or disease-producing form. Its mycelial development, which is very limited, takes place just beneath the cuticle, as shown to the right in figure c, Plate VI, which represents a vertical section, highly magnified, through a minute outer portion of an infected berry. In the same figure, to the left, the fungus is seen to have burst through the cuticle and thrown up a multitude of very short stalks, upon which the spores are produced. A section made through an old diseased spot, more highly magnified, is shown at *d*, Plate VI. The entire surface here appears to be covered with a great multitude of spores held together by their mucilaginous coatings. Water dissolves this covering; this effected, the spores will separate from each other, and, viewed singly, they appear as oval or oblong, transparent bodies, rounded at the ends and often slightly constricted near the middle. Two bright spots resembling nuclei are usually visible in each spore. With the aid of dew or rain these spores are spread, and De Bary succeeded in transplanting them with the assistance of a few drops of water upon green and healthy parts of the vine, where there were produced in about eight days the characteristic spots of Anthracnose. In often repeated experiments the disease showed itself exactly at the points infected and nowhere else. Mr. Goethe performed similar sowings of the fungus spores and always with a like result.* The germination of the spore in water takes place quite rapidly and there is formed an irregular germinal thread—the beginning of the mycelium, as shown at *e*, Plate VI. The germ-tube penetrates the epidermis, just beneath which is developed the vegetative growth of the *Sphaceloma.* As stated above, other spore forms for this fungus have never yet been certainly traced, and consequently it is not definitely known how the fungus passes the winter, and it is hardly worth while to speculate upon the subject at this time.

REMEDIES.

As in the case of the Mildew and other diseases of the vine, a great variety of means have been employed and many substances tried to either prevent or cure Anthracnose. It has already been noted that certain varieties are more subject to this disease than others, but if we attempt to avoid the Anthracnose, the Black-rot, and the Mildews by

* "The disease can be readily transferred artificially from an affected to a healthy berry. It is only necessary to wet with water a diseased spot, and after stirring with a little brush, remove some of the water to a healthy fruit, where it may stand as a little drop. If this is done when the air is saturated with moisture, failure to communicate the disease rarely happens."—Burrill in *Proc. Am. Pom. Soc.*, 1885, p. 49.

a system of selection based upon this principle, we will have to discard grape culture entirely, or at least all those varieties which we prize most highly. Certain kinds that usually escape the Mildew are in some cases the very ones most "susceptible" to the Black-rot, and those which may "resist" the latter malady may be the first to succumb to the Anthracnose.

It is certain that the latter disease prevails most in wet seasons and in low situations or upon poorly-drained land. Too high manuring, especially with fresh stable-dung, seems to favor the development of this parasite.

As with the *Peronospora*, water in a condensed form is necessary for the diffusion and propagation of the disease under consideration, and any appliance that shall prevent deposition of rain or dew upon the foliage or other parts of the vine will secure immunity from the disease. Inclosing the half-grown bunches of grapes in paper bags will doubtless be as useful a protection of the berries against Anthracnose as from Black-rot, and for the same reasons. This system of vine protection, excepting for the berries, is hardly practicable in vineyards of any size, and other remedies of more general application must be sought.

The *Sphaceloma*, as has been shown, grows very near the surface, and as soon as it has burst through the epidermis it is practically exposed in all its parts to the direct action of fungicides. Much mischief to the vine may be done before this exposure of the mycelium and spores takes place, and, consequently, here as elsewhere, prevention is vastly more valuable than cure.

In districts in Europe subject to this disease the practice is quite generally followed of bathing or washing the vines, in early spring, before the buds have commenced to expand, with a strong solution (50 per cent.) of sulphate of iron, applied with an ordinary mop or a large sponge fixed to the end of a stick 2 or 3 feet long. This washing should be done when the atmosphere is damp, in order to prevent a too rapid evaporation of the iron solution, which otherwise might result in injury to the vine. When the young shoots have attained a length of 5 or 6 inches they receive a good dusting with the flowers of sulphur, whether the disease has appeared on them or not. The new growth is then carefully watched, and at the first sign of the malady they are again treated, this time with sulphur, to which has been added one-third to one-half its bulk of powdered lime. If the progress of the disease is not checked by this treatment the sulphur is omitted in subsequent applications, which are of finely pulverized lime.

Where this treatment of the vines with sulphate of iron, followed by heavy and frequent use of sulphur or sulphur and lime, has been adhered to for several years, Anthracnose now rarely appears, or has ceased to be injurious, even in locations where before it was exceedingly destructive.

V.—GRAPE-LEAF BLIGHT.

(*Cercospora viticola*, Sacc.)

The disease here named "Grape-leaf Blight" is analogous in nature to the disease of the strawberry called "Strawberry Rust," or to that of celery, popularly referred to as "Celery Blight." In each case the special external characters are induced by fungi of the same group.*

In a visit to the vineyard of Col. G. F. Needham, of Seabrook, Md., June 15 of the present year, it was observed that several varieties of grapes of the Riparia class had their lower and more shaded leaves more or less thickly covered with rounded or irregular brown spots, varying in size from $\frac{1}{24}$ to $\frac{1}{8}$ of an inch in diameter, with a clearly-defined darker colored and slightly thickened or elevated border. The discolorations extended through the thickness of the leaf, but while the diseased areas on the upper surface were perfectly smooth there could be seen, with the aid of a pocket lens, on the under side numerous projecting hair-like points. These indicated the presence of some parasite, and removing one of these fine projections and examining it with a power of 250 diameters, it was seen to consist of a closely-packed bundle of slender unbranched tubes with rounded and somewhat irregular spreading tips (see Plate VII, b). Each of these tubes, which are collectively termed hyphæ, had several cross-walls or septa, and they appeared to spring from a cushion-like base or stroma, attaining the height of from 150μ to 300μ. Upon the tips of some of the hyphæ were attached elongated and somewhat club-shaped spores (30–90μ by 6–8μ), rounded at the thickened apex and tapering abruptly below into a slender stalk-like base. These spores, like the hyphæ, were of a pale olive brown, and were divided by cross-walls into from 3 to 13 cells. Several of these spores are shown on Plate VII, b, some still attached to their supports, others free. When sown upon a drop of water they germinate readily, sending out slender filaments from either extremity or from the lateral walls of the component cells, several filaments often issuing at once from the various parts of the spore. Should one of these germinating spores fall upon the surface of a leaf and find there the conditions favorable to its further development, the germ-tubes would penetrate the epidermis, and, spreading more or less extensively within the tissues, produce the characteristic brown spots by killing the cells from which they absorb their food. As the disease progresses the tissues of the leaf in the vicinity of the spots become affected, changing to a pale green or yellow, and finally the whole leaf perishes. In the

*It would be well to restrict the term "Rust" to those plant diseases caused by species of the order *Uredineæ*, *e. g.*, "Wheat Rust;" and although the term "Blight" has been used to designate the diseases caused by fungi of the order *Perisporiaceæ*, it may be well to adopt for the latter the general term "Powdery Mildews," and limit the use of the term "Blight" to diseases caused by *Ramularia*, *Cercospora*, &c.

process of development the mycelium of the fungus within the leaf forms a condensed growth in the air-spaces just beneath, or rather just above the stomata or breathing pores of the lower surface, and it is from these condensed masses that the column of slender tubes or hyphæ above described arise and pass out through the opening of the pores.

This "Blight" when prevalent may cause considerable damage to the foliage, and consequently to the vine, but unless the season be a very wet one it is not likely to do much damage, excepting perhaps in low or damp situations or upon vines improperly cared for.

The form of this fungus above described, and figured on Plate VII, is the only stage in its development yet known. What other spore-forms there may be, or how the fungus passes the winter, remains to be discovered. Aside from the specimens found by myself in Maryland, I have seen others from New Jersey* and South Carolina.†

This fungus has been named *Graphium clavisporium*, B. and C., but all the specimens I have seen so ticketed accord perfectly with *Cercospora viticola* as described by Saccardo in *Sylloge Fungorum*, IV, p. 458, and are in all respects like the fungus described and figured by Viala in *Maladies des Vignes*, under the name of *Cladosporium viticolum*. Through the kindness of my friend Mr. J. B. Ellis, of Newfield, N. J., I have been enabled to examine European specimens of the *Cercospora viticola*, and I find the points of resemblance between this and our *Graphium clavisporium* so close that I have been led to regard them as one and the same; and, believing it a good *Cercospora*, I have adopted the name given it by Saccardo.‡

VI.—GRAPE-LEAF SPOT.

(*Phyllosticta Labruscæ*, Thüm.)

In the latter part of May, and from that time until past midsummer, the leaves of almost any variety of grape in the open vineyard may be seen to be diseased by what is here designated as "Grape-leaf Spot," the direct result of the action of a fungus allied to that which causes the Black-rot.§

Attention was first called to this malady by Dr. George Engelmann in the *Transactions of the Saint Louis Academy of Sciences*, June 5, 1878. After describing the external and minute characters of the fungus, Dr. E. remarks that this parasite makes its appearance just before and

* Ellis, *N. A. F.*, No. 132; and von Thümen, *Mycotheca Universalis*, No. 1574.

† Ravenel, *Fungi Carolin.*, No. 77, and *Fungi Amer.*, No. 776.

‡ Since writing the above I have learned that *Graphium clavisporium*, B. and C. and *Cercospora viticola*, Sacc. have been regarded as identical by the Italian botanist Pirotta, and also by the well-known English mycologist, Mr. M. C. Cooke. The last-named gentleman thinks the fungus belongs to the genus *Helminthosporium*, and expresses surprise that Saccardo should have placed it in the genus *Cercospora* "with which it has no affinity" (Grevilla, VI, p. 149).

§ Viala, in *Maladies des Vignes*, considers this only a form of the Black-rot fungus.

during the flowering period, and attacks, as far as he had observed, only the leaves, which, when abundant, it kills and thus cripples the vine. Believing the fungus to be undescribed, the doctor named it *Depazea Labruscæ*. I am indebted to Prof. C. V. Riley, United States Entomologist, for samples of the leaves studied by Dr. Engelmann; and the fungus upon them, as kindly determined by Mr. J. B. Ellis, is the *Phyllosticta Labruscæ* of von Thümen.

The diseased spots are of a clear reddish brown, sharply defined by a narrow and darker colored border. They have a rounded outline and vary in size from $\frac{1}{10}$ to $\frac{1}{2}$ an inch in diameter. When the spots are numerous they often run together, forming irregular brown patches that sometimes cover a considerable portion of the area of the leaf, but the circular outline of the original spots remains visible even when the patches have extended so far as to embrace nearly the whole leaf.

When the spots are few and scattered, little injury results, although the tissues included by them are completely killed. Those leaves, however, that have been more severely attacked, and upon which the spots are numerous, are very quickly destroyed.

If one of the diseased spots be closely examined, there will be seen scattered over the surface, but most abundant in a sort of ring just within the border, a large number of minute black bodies. These can be seen with the naked eye, but they are most clearly discernible with the aid of a pocket lens. These black bodies are the perithecia or spore cases which are formed upon the mycelium within the tissues of the leaf and pushed up through the epidermis, and are similar to those described under Black-rot. They are filled with a vast number of minute round or ovoid spores which escape through a minute opening or osteolum, at the top of the perithecium. The latter vary from 70μ to 130μ in diameter, while the spores are from 8μ to 10μ in their greatest length. The latter are clear, and appear to be filled with granular transparent contents. These spores are attached to the walls of the perithecia by very short stalks or basidia. Among the many perithecia that I examined one only was found filled with what have been called spermatia (see description of botanical characters of Black-rot).

It is very probable that this fungus lives through the winter in the affected leaves, and in the spring develops into some sphræiaceous form producing ascospores. Whether this form is known or not I cannot say, but it is certain that no connection has ever been traced between the *Phyllosticta* under discussion and any more perfect stage.

The same conditions which favor the development of the Downy Mildew and the Black-rot, also favor the Leaf-spot disease, but the injury inflicted by the latter is by no means comparable to that occasioned by either of the former; however, it belongs with the parasites injurious to the vine, and grape-growers will be interested in knowing its nature and in being able to recognize it.

There is another but less common species of *Phyllosticta* (*P. viticola*, v. Thüm., *Septoria viticola*, B. and C., *Sacidium viticolum*, Cooke), which produces similar spots upon the leaves of *Vitis vulpina*. In this case the minute black bodies, or perithecia, are abundant on both sides of the leaf—in *P. Labruscæ* they occur only on the upper surface—and each spore has a large and clearly defined transparent vesicle.

No remedies are known for either the "Leaf-blight" or "Leaf-spot" diseases, but it is very probable that the general treatment advocated for the Downy Mildew and Anthracnose will have a direct tendency to limit their development.

APPENDICES.

Appendix A.

SYNOPSIS OF REPLIES TO A CIRCULAR RELATIVE TO GRAPE MILDEWS AND GRAPE ROT IN THE UNITED STATES.

By Erwin F. Smith.

To inquiries by this Section relative to the prevalence of grape-rot and the mildews in the grape-growing districts of the United States, there were received 384 replies from 366 localities, in 41 different States and Territories.

THE MILDEWS.

Of all who reported, 202 had neither observed nor heard of the mildews in their county, or did not know them, or did not state. One hundred and eighty-two persons, in nearly as many localities, stated the presence of *Uncinula spiralis* or *Peronospora viticola*, or both, with varying degrees of injury to the vineyards. The reported loss, depending upon the locality and the season, ranges from "slight" to "total." Nearly one-third of all who reported stated the loss in the vineyards of their section to be, in bad years, from 25 to 50 per cent. of the crop, and, in some instances, in particular vineyards or upon certain varieties, the entire crop. If the reports received can be taken as fairly indicative of the loss from mildews throughout the grape-growing regions of the United States, then it may be positively stated that during the past ten years this has been as much as 10 or 15 per cent. annually.

POWDERY MILDEW.

Almost without exception, *Uncinula spiralis* is reported to do serious injury only in dry districts, or during severe drought, and chiefly to foreign grapes and a few natives, such as the Delaware. In a few cases a loss of from 10 to 50 per cent. or more is ascribed solely to *Uncinula*. This fungus is widely distributed in the United States, ranging from Massachusetts to Georgia, and westward across the continent to the Pacific, but the losses occasioned thereby, in the country as a whole, appear to be trifling.

DOWNY MILDEW.

Peronospora viticola occurs in nearly all parts of the United States, on wild as well as cultivated sorts. Even the Pacific coast, which long enjoyed perfect immunity, is not now free from it. During the last year at least eight different counties in California reported its presence, with losses on certain varieties ranging from 5 to 100 per cent. It is found also in Utah, and probably occurs in Oregon. It is most prevalent from the mid-Atlantic coast district west to the Mississippi, and southwest into Texas. This fungus everywhere injures the vineyards, often attacking fruit as well as leaves. It occurs on the vines throughout the growing season, but is usually worse from June to August. All report its growth to be favored by warm and wet weather, particularly by hot weather following protracted rains. In bad seasons all varieties, without exception, are subject to its attacks. Those esteemed particularly hardy and free from it in one locality succumb to it in another, or even in the same locality another year. On the whole, the varieties reported most free from it are Scuppernong, Norton's Virginia, and Ives' Seedling. Almost the entire loss from mildew must be attributed to *Peronospora viticola*, since, as above stated, *Uncinula spiralis* does serious injury only in a few restricted districts.

REMEDIES AND PREVENTIVES.

The remedies most commonly tried for mildew have been sulphur and lime, though many others were mentioned. None of them seem to have given uniform or satisfactory results, except, possibly, sulphur in the case of *Uncinula*, which grows upon the surface of the leaves, stems, and fruit, and can be reached directly. In the grapery, moisture alone appears sufficient to check the growth of this parasite. The only conclusion reached by a consideration of the replies is that sulphur, lime, copperas, and other remedies, so far as tried in this country, are of doubtful utility in case of *P. viticola*, the mycelium of which grows deep within the tissues of the leaf and berry, where it cannot be reached by external applications. Many cases of apparent benefit from external applications are unquestionably attributable to accident, to changes in the weather, or to other causes not within control of the grower.

In the hands of some grape-growers a remedy may seem to give excellent results, but before it can be accepted as really useful it must be tried in many localities and during a series of years in order to eliminate all sources of error. If applications are made to the vines in years when, from dryness or other natural cause, fungi of all sorts are unusually scarce, then, unless very carefully-conducted control experiments are made at the same time, it is easy to see how results due solely to the season or location might be ascribed to the remedy. Hasty generalizations from a few observations and experiments are very common,

but almost always lead one widely astray. In reference to all proposed remedies, it may be said, only when the disappearance of the fungus uniformly follows the application of the remedy are we warranted in attributing this to its use.

THE BLACK-ROT.

DISTRIBUTION, VARIETIES ATTACKED, ETC.

Two hundred and twenty-nine persons reported the presence of black-rot.

The territory over which *Phoma uvicola* is reported includes the chief vine-growing regions of the United States, and coincides with the mildew district, save that no rot is reported west of the Rocky Mountains, except doubtfully in one instance, and but very little north of latitude 43°. In some districts this fungus has been under observation for more than twenty years, and in many, during the last decade, it has done serious and increasing injury. It usually attracts attention about the time the grapes are beginning to color, or a little earlier, and in very warm, wet seasons may, within a week or ten days, destroy the whole product of a vineyard. As in the case of *Peronospora viticola*, its growth is said to be greatly favored by warm and wet weather, and entirely stopped by a protracted drought. The Concord, Catawba, Isabella, Hartford Prolific, and Rogers-hybrid varieties seem most subject to this rot, and the Delaware and other light-colored or white varieties least; but no variety is entirely free from its attacks, unless it be the Scuppernong, which is said to be harmed by nothing. Many persons report all varieties equally subject. Often those reported "iron-clad" and "rot-proof" in one locality are said to be very badly affected in some other.

STATEMENTS OF CORRESPONDENTS AS TO PREVALENCE AND DESTRUCTIVENESS.

Judging from the reports received, the loss occasioned by this rot is far more serious than that attributable to the mildews. Many report the loss of nearly their entire grape crop for a series of years, and state that they have dug up their vineyards, or will soon do so, if a remedy cannot be found. The following are characteristic quotations from letters received from badly-stricken localities:

Renders the cultivation of *Labrusca* and *Æstivalis* varieties unprofitable. (G. W. Davis, Jacksonville, Fla.)

All hybrids are much subject to its attacks, and almost worthless in consequence. (David Milen, Macon, Ga.)

For the last five years I have not had an average of 200 pounds per acre, and on many vines not a grape has matured. (W. W. Patch, Galesburg, Ill.)

Grape culture was formerly very profitable in this county, but, owing to the ravages of the black rot, it is now almost wholly abandoned. (Theodore Goodrich, Cobden, Ill.)

The rot comes suddenly, and quits as suddenly. About one-half of mine rotted in one week. (P. A. Hickman, Mount Sterling, Ill.)

The rot is worse in wet seasons. Sometimes the entire crop fails on account of it. (G. W. Mosteller, Crawford County, Kansas.)

The black-rot appeared gradually, and continued until the crop was utterly worthless. I dug up one vineyard. (J. Wallace, Cambridge, Md.)

Many acres were formerly planted, but now, on account of the rot, few vines are grown. In this county alone many thousands of dollars have been lost by the rot. (John J. Maxwell, East New Market, Md.)

For the last two years a large firm of wine-makers at Hermann, Mo., has been buying grapes across the river, at Wathena, for $60 per ton. On account of rot, the vineyardist who furnished the company four car-loads year before last could furnish only one car-load last year. (Joseph L. McAleer, Saint Joseph, Mo.)

Loss about 60 per cent. Nothing I have tried does any good. (John W. Mansfield, Plato, Mo.)

In the year 1869 I made a specialty of grape culture, and planted a vineyard of 5,000 vines, mostly Concord. For three years abundant and perfect crops were the result, without any show of disease, when the black-rot made its appearance on a few vines, and each year thereafter gradually extended until the loss was so great that I was obliged to discontinue grape culture, taking out the vines, except a few hundred, two years ago. In a vineyard of 10,000 vines, at Kidder, Mo., near Hamilton, the black-rot has been equally destructive, and the vines have all been taken out. Loss fully 90 per cent. in this county. (N. B. Bell, Hamilton, Mo.)

I have about 3,000 vines in my yard, and have among them Concord, Norton's Virginia, and Delaware as the principal crop; also all, or nearly all, kinds of Labrusca, with many Vinifera, a number of Riparia, with nearly all of Rogers' Hybrids. The greatest rot is among the following in the order in which I give them: Concord, Champion, Brighton, Dutchess, Prentiss, Agawam, Goethe, Elvira, Catawba. The foregoing were almost a total loss—practically were a total loss—as the cost of sorting and cleaning out the rotten berries was more than the residue in the shape of dilapidated bunches of grapes brought when sold.

The Martha rotted to the extent of 50 per cent. of its crop; the Herbemont about the same; Norton's Virginia no perceptible damage; about 25 per cent. of the crop of Delawares suffered from a grayish rot that injured the grapes, leaving some of them apparently sound, but with a bitter taste that followed the grape into the wine-vat and left a bitterness in the wine that was offensive. With us the only vines that are profitable are the Norton's Virginia, and, to some extent, the Delaware; the latter suffers greatly from mildew and other diseases, and the vines have the appearance of weakness in the wood.

Usually we have a good deal of rainfall in April and May, which is followed by hot close weather, which in May develops the rot. If it turns dry the rot clears, but if it rains to any great extent it commences again. This season [1886] has been unusually dry, no rainfall at all since last April; hence, up to the present day, all the grapes are free from all appearance of rot. I never saw the vines and grapes looking so healthy as they do at present, which indicates that our troubles come from excessive moisture. (Edward Perry, Denison City, Grayson County, Texas.)

As early as 1871 or 1872 the black-rot appeared in some vineyards here, but was not general until 1876; then for about six years the loss was almost total. I think my loss on two thousand vines was $300 per annum. (V. H. Porter, Forest Grove, N. J.)

Loss was light at first, but in three years it took my entire crop of Concords, and is doing so in other vineyards in this neighborhood. (—— ——, Egg Harbor, N. J.)

On account of the prevalence of the black-rot I have abandoned the cultivation of the grape. For several years in succession the crop was a complete failure. (J. M. Demarest, Mountain View, N. J.)

Last year, taking an average for the whole county, the loss occasioned by the rot was about 30 per cent. The average for the last five years is about 70 per cent. (Joseph Nehr, Egg Harbor City, N. J.)

In general, our vintners do not fear, and have not taken any account of the ravages of mildew; perhaps if the black-rot had not been prevalent to such a large extent it would have attracted closer observation. As to my condemnation of hybridized grapes being more prone to the attack of the black-rot, I may instance that for a number of years I have tested Othello, Cornucopiæ, Alvayse (received from your Department), and, in conjunction with Concord, found them to be the first and worst attacked of any varieties, so that I was reluctantly compelled to displace them for other more iron-clad varieties. (V. P. Hoffman, secretary E. H. C. Agricultural Society, Egg Harbor City, N. J.)

I am in receipt of your letter inquiring what I "believe to be the actual and probable loss occasioned by any one of the well-known fungus diseases of plants." For example, as regards grape-rot, probably the loss occasioned by it to the grape crop of the United States (outside of California) amounts to one-fourth. Loss from rot and mildew, the two fungus diseases together, may be estimated at 50 per cent. of the crop. In Southern New Jersey, during some ten years, the loss on the grape crop, financially speaking, was total—that is, the cost of the vintage was more than it yielded. (Alexander W. Pearson, Vineland, N. J.)

In this part of the State ten or fifteen years ago black-rot was more prevalent than now. It was so bad then that most of the vineyards of the county were abandoned. At this date the loss per annum is about 25 to 30 per cent. (G. F. Newton, Millersburg, Ohio.)

In years past grape-rot has destroyed hundreds of tons of grapes here, so that nearly every vineyard has been dug up. I have seen the produce of whole vineyards destroyed in three or four days, the last of June or the first of July. The kind of weather that used to rust wheat seems to breed this pestilence. (T. L. Whiteacre, East Rochester, Ohio.)

The rot appeared in our vineyards in 1878, and for seven years past it has destroyed the entire crop. All varieties have rotted, and almost all the vineyards in this vicinity have been dug out. I had 12 acres and dug all out. Our grapes rot without mildew or any apparent disease of the vine. (F. R. Palmer, Mansfield, Ohio.)

The rot appeared first in 1884, and it has increased every year since. It destroys three-fourths of the crop. My crop is too far gone this year [July 2, 1886] to try any remedies. (Charles Hek, Rustburg, Va.)

The black-rot appeared about the year 1872. It attacks all varieties cultivated, and the loss per annum is 90 per cent. I have tried no remedies except to dig up and burn the vines, and abandon further investments of time, labor, and money in that direction.

I was the pioneer in planting vineyards in my county (Alexandria County, Virginia). I planted my first vineyard in the spring of 1866, finishing this month twenty years ago. * * * The summer of 1868 the vines yielded a fair crop of grapes, which were as fine and perfect as ever grew, and which sold for 15 cents per pound *on the vine*. The next three crops were as beautiful and as perfect. The fifth year now and then a grape on a bunch was discovered that had dried up and turned black. The next year there were more, and so on until now for several years the crop has nearly all rotted, and I have abandoned their cultivation. The total damage to me so far by said rot will amount to about $12,000. (R. A. Phillips, 1428 New York Avenue, Washington, D. C.)

The black-rot has prevailed three or four years. It is very destructive in some vineyards in the south part of Berrien County. The loss last year [1885] was, perhaps, about one-fourth, but this season, by reason of extreme dry weather, the injury is less. The Catawba, Isabella, Niagara, and Concord are most subject to its attacks. The Hartford, Ives, Delaware, and varieties which color and ripen early are comparatively exempt.

No remedies are found to be efficient. I have applied sulphur in large quantities with no apparent effect. Some vineyards, where last year the crop was entirely de-

stroyed, were cut to the ground last spring. The theory prevails that by destroying the crop one season the spores of the fungus which causes this rot will be destroyed or checked, so that the succeeding year a crop can be grown upon young vines. This theory remains to be proved. No doubt is entertained by our intelligent growers regarding the cause of the black-rot. When a vineyard becomes affected and rotten grapes fall to the ground, the spores of this fungus are matured in the ground during the winter and spring. Then, under favorable circumstances of warm and wet weather, the spores become detached, and, floating in the air, attach themselves to the young, growing grapes, at first causing a very minute "speck," which soon spreads over the grape.

The disease is not communicated by contact of a rotten grape with a sound one. Usually several attacks occur during the season, each being induced by conditions of the atmosphere favorable to the development of the spores of this fungus. The black-rot has spread over a very wide area of country. It is advancing northward in the Michigan peninsula slowly but surely; and, if no remedy is discovered, it will render grape-growing extremely precarious in all parts of the country. (W. A. Brown, Benton Harbor, Mich.)

ESTIMATED LOSS.

In my opinion, which is based upon the above-mentioned special reports (384), and on other available and trustworthy information, the *annual loss* from grape-rot during the last ten years in the principal vine-growing regions of the United States *has not been less than one-fourth of the entire crop.*

REMEDIES.

Many remedies have been proposed for grape-rot, but none appears to be effective. Perhaps no substance will ever be discovered which can be depended upon to destroy the growing *Phoma* and arrest the rot without at the same time injuring the vines themselves.

PREVENTIVES.

By way of prevention, which is really more important than cure, two methods seem worthy of extended trial. These are:

1. *Prompt removal and burning of all diseased grapes.*
2. *Protection of the grape clusters from rain and dew.*

The first method has been tried with uniform success* in Michigan, New Jersey, South Carolina, Tennessee, Mississippi, and other States. This method is based upon sound principles. The grape-rot is an infectious disease, propagated by diseased berries. Every rotten berry

* The best remedy for the rot is undoubtedly picking off the rotten berries every day. This stops the spreading of the disease. (G. Wanner, Walhalla, S. C.)

Last year [1885] was the first season the black-rot made its appearance in my vineyard of one acre. I promptly picked off the affected fruit and buried it. Out of a crop of 5 tons I had only about 10 pounds of the affected grapes. The disease made its appearance when the berry was nearly full grown. I use ashes and lime as a top dressing, spreading it broadcast, and, as they become affected, promptly pick off the grapes and destroy them. I expect to keep the grape-rot in check by picking off and destroying the diseased fruit as soon as it makes its appearance. One of our reliable fruit growers told me he had succeeded in keeping the rot in check by following that method. (W. T. Withey, Benton Harbor, Mich.)

is, or may become, a center of infection. Consequently, the chances that the rot will spread decrease in proportion to the thoroughness with which this infectious material is removed and destroyed. The berries should be picked off every day until the rot disappears, and should in all cases be burned or buried. Where this treatment has been systematically followed, for even a single year, great benefit has been experienced the year following. To be most effectual the picking should be practiced every year from the time the rot begins until it ceases, and should be so thorough that no diseased grapes are left either upon the vines or on the ground. The labor of removal, at first onerous, will become less and less each year. To render the work most effective there should be concerted action among all the grape-growers of a district.

The second method, the protection of the fruit from moisture, is based on the well-known fact that the spores of *Phoma* will not germinate if kept dry, and on the oft-recorded observation that the rot almost entirely disappears in times of drought. In many parts of Southern Michigan the summer and autumn of 1886 were characterized by a protracted drought, not a drop of rain falling for six or eight weeks. During this dry weather the rot disappeared almost entirely. I made several examinations in September, in three different counties, but failed to find a trace of rot even in vineyards where it was very prevalent in 1885.* There are two ways of keeping the grapes dry:

(*a*) By covering the individual clusters with paper bags.

(*b*) By roofing the trellises with wide boards or with cotton cloth.

Bagging is almost uniformly successful if done carefully, and early in the growing season, *i. e.*, soon after the grapes have set and before the spores of the *Phoma* have lodged thereon.

Mr. J. C. Hodges, of Morristown, Tenn., writes:

> For twelve years my experience has seemed to demonstrate that dampness on the surface of the fruit and rapid growth of foliage are the causes of the disease. Shelter of any kind over the vine prevents it every time. Small paper sacks over the bunches save them perfectly. The remedy I have used most, with almost uniform success, is leaf pruning. I allow the canes to grow full length, but in June I cut away the older leaves and suckers from near the fruit, so as to allow free circulation of air, and so that the sun may shine on the fruit. Except on rich land or when there is a long-continued, cloudy spell, this saves the fruit. Nothing but shelter or sacking the bunches will save it on rich land.
>
> I have never seen disease of any kind attack fruit or vine when the vine is trained along the wall or under the eaves of a building. I have seen a shelter 2 feet wide made over the trellis prove a complete protection against rot, while on the same vine, where it bore fruit not under the shelter, not a grape matured.

Respecting the roofing of trellises, Col. Alexander W. Pearson, of Vineland, N. J., who has had large experience, also says, "It gives almost complete protection."

If practicable, both methods may be combined.

* "A dry May brings a good crop," is a common saying among grape-growers.

With many viticulturists it may be an open question whether the profits of grape-raising will warrant the cost attending the application of these preventive measures. It is hoped, however, that they will be given careful trial, and that grape-growers will report results to this Section.

PER CENT. OF CROP ANNUALLY DESTROYED BY ROT AND MILDEW.

In some instances observers have not clearly distinguished the loss due to the mildews from that due to the rot. The fact that they generally occur together renders this the more difficult. In a good many localities, in the years when the mildew prevails, the loss is chiefly from the rot; but the rot also appears to prevail where *Peronospora viticola* is unknown or infrequent.

For the United States east of the Rocky Mountains the entire loss from mildews and black-rot cannot, on an average, be much less than 40 per cent. annually. This is lower than Mr. Pearson's estimate, and lower than I would be warranted in placing it, if I based my judgment exclusively upon the reports received.

VALUE OF THE PRODUCT DESTROYED.

Owing to our ignorance of the total grape-product of the United States the pecuniary loss cannot be very accurately determined.

Some of the principal grape-growing States are Missouri, Illinois, Ohio, Michigan, Pennsylvania, Maryland, New Jersey, and California. Probably more grapes are grown in these States than in all the rest of the United States, but in most of them the records are imperfect. If we knew the total grape-product of the United States for a series of years, or, in other words, if our State and National crop-reporting systems were as complete and accurate as the agricultural interests of the country demand, it would not be difficult to make a close estimate of the value of the grapes destroyed by rot and mildew. As it is, we must be content with such scanty and imperfect returns as are accessible.

The "Farm Statistics" of Michigan, which are carefully compiled from the monthly returns of 1,400 special correspondents, and considered trustworthy, state the number of pounds of grapes sold in Michigan, and from these I have compiled the following table:

TABLE I.—*The approximate grape-product of Michigan during the four years*, 1882–1885.

Year.	Pounds sold.	Value at .03 per pound.
1882	3,089,474	$92,684
1883	1,004,757	30,143
1884	2,603,884	78,116
1885	*3,710,000	111,300

*From unpublished statistics, furnished by Mr. Robert L. Hewitt, chief of statistics, department of state, Lansing, Mich., and subject to final revision.

Table II. covers a longer period, and is presumed to be reasonably correct, but I have no means of knowing how accurately the returns were made:

TABLE II.—*Showing the grape-product of Ohio for the twenty-one years,* 1865–1885.

[Compiled from returns by the county auditors* and from other official sources, as published in the State Agricultural Reports of Ohio.]

Year.	Acres.	Yield per acre in pounds.	Total number of pounds gathered.	Gallons of wine pressed.	Value of entire product.
1865	5,666	439	2,487,607	237,008	.....
1866	7,162	205	1,469,467	153,159	.....
1867	7,304	757	5,526,227	290,929	.....
1868	7,574	388	2,937,737	143,767	.....
1869	10,477	362	3,794,899	155,535	.....
1870	10,890	1,459	15,853,719	2,577,907	.....
1871	11,219	1,720	19,292,980	1,031,923	.....
1872	15,111	636	9,616,427	425,923	.....
1873	11,560	571	6,607,653	208,289	.....
1874	9,975	1,801	17,965,604	1,078,056	.....
1875	8,130	825	6,703,408	199,948	.....
1876	8,321	1,337	11,127,969	537,192	.....
1877	8,695	1,279	11,119,401	488,419	.....
1878	8,866	1,167	10,341,715	708,733	.....
1879*	18,114	906	16,308,151	961,702	$2,009,479
1880	10,315	1,796	18,526,219	1,296,295	2,685,491
1881	10,642	1,097	11,678,545	884,895	2,336,931
1882	12,091	2,275	27,503,000	1,465,336	4,305,150
1883†	9,377	†660	6,191,072	261,787	†702,235
1884	11,924	1,752	20,895,563	938,671	2,452,785
1885	17,292	523	9,043,216	439,610	1,021,144

*After 1878 a different and more complete system of returns was adopted. The grapes are estimated at .04 per pound for 1879, 1880, 1881, and 1885; and at .05 for 1882, 1883, and 1884. The wine is valued at $1.50 per gallon for 1879, 1880, 1883, 1884, and 1885; and at $2 for 1881 and 1882. The estimated value for the years prior to 1879 is not given.

† In 1882, in the vine-growing districts of Michigan and Ohio the late summer and the autumn were dry, and there was comparatively little mildew or rot. In 1883, in both States the spring was cold and wet, and during June and July there was a long-continued spell of wet weather. The grapes mildewed and rotted very badly in both States. In Ottawa County, which grows more grapes than any other county in Ohio, the Catawbas promised well in the spring, but almost the entire crop rotted in August.

Appendix B.

REMARKS ON GRAPE ROT AND GRAPE MILDEW.

By Col. Alexander W. Pearson, *Superintendent Vineland Wine Company, Vineland, Cumberland County, New Jersey.*

The region known as the "Vineland Tract," in Southern New Jersey, since its settlement in 1861, has been largely devoted to grape culture. The vines, principally Concord, were healthy for some years and yielded profitable crops.

About the year 1869 "the grape rot" appeared in South Vineland, thence gradually spreading and increasing in virulence as it spread. In a young vineyard which I purchased in 1872, then bearing its first crop, the manifestations of the disease were scattering and slight; the next year a greater per cent. of the crop was damaged, and by 1876 the destruction caused by rot was nearly total.

Microscopic inspection showed the disease to be the work of a fungus, now known as *Phoma uvicola* and distinguished by a European botanist (von Thümen) as being of American origin. In his work (Die Pilze des Weinstockes—The Fungi of the Grape-vine) he describes this *Phoma* as known to him only through specimens sent from Southern New Jersey and from South Carolina.

It appears usually when the berry of the grape is about two-thirds grown, the dates of its first appearance each year in this latitude varying from June 20 to July 10. A small, whitish spot, about one-sixteenth of an inch in diameter, surrounded by a brownish areole, appears on or in the epidermis of the grape. This areole enlarges until the entire superficies of the berry is involved. It is then dark-brown and is studded with a multitude of minute black pimples, which are located immediately beneath the outer skin. These are the *perithecia* or seed capsules of the fungus. When they are matured, which is in about twenty-five days from date of apparent infection, they burst, rupturing the epidermis of the fruit, and extrude a mass of spores.

Only familiarity with its appearance beneath the lens can give one a realizing sense of the almost boundless fecundity of this *Phoma*. And this must be comprehended before we can account for the visible symptoms of the disease as manifested in the vineyard.

In the early years of its prevalence certain observers specified as diagnostic of this peculiar rot the mark of but "a single rot-speck on each berry." It now seems that this apparently sporadic character of the initial infection was simply due to the scattered distribution of the germs while they were yet comparatively few in number. After successive crops of the *Phoma* these germs multiplied so that single berries often exhibited numerous "rot specks" or points of initial infection. I have counted seventeen on one grape, and have seen the entire crop of a vine, say 25 pounds of fruit, destroyed by a single invasion of the *Phoma*, not a berry escaping.

Some writers have regarded the disease as constitutional, existing in the circulation of the vine and imbibed through its roots, the symptoms developing similarly to the eruption of small-pox in man; but it is now proved that the infecting germ of the *Phoma* floats in the atmosphere, whence it alights upon and takes root in the exterior of the grape. Disseminated by the wind, these germs drift abroad as do the atoms of vapor in a fog, and thus gradually spread from place to place. I have seen this invasion from an old and infected vineyard into and through the rows of a young vineyard planted beside it, the row of young vines contiguous to the old being nearly stripped of fruit by the rot, the next row less damaged, and so on, until the tenth row distant gave scarcely a sign of the infection. So in the uncultivated territory which surrounds the infected region, where new farms are opened and new vineyards planted, which are yet comparatively isolated, and which we see are for a time healthy, we have yearly the proof that the presence of the infecting germ is a prerequisite to production of symptoms of the disease.

In an infected vineyard these germs hibernate upon the fallen and rotted berries and dried petioles of the vine. Their vital activity is developed and their capacity for infection is aided by warmth and moisture. After the germination of the first crop of the *Phoma* in the summer, which is doubtless produced from the débris in the vineyard, successive attacks come during August and September from the spores set free from the perithecia as they mature and rupture in the rotting grape.

But if drought, intense, as it sometimes is in this locality, prevail at the season when grape rot is to be expected, the disease will not appear until there is a moist atmosphere.

I once thought, and so stated, that I had traced the appearance of rot as supervening upon the occurrence of a local shower after a severe drought, during which our vineyards remained healthy; that is, I ascribed it to the actual presence and precipitation of atmospheric moisture, but observations made this summer (1885) convince me that I was mistaken. During May and June drought was continuous, and my hygrometer gave no indication of moisture in the air. While this favorable condition for health of the grape endured there was no sign of disease.

On Friday p. m., July 10, my farm was visited by a local shower tolerably copious. On Saturday p. m., I found in my vineyards the first signs of rot. On Sunday a. m., I was visited by neighbors who had been likewise afflicted by the rain. They discovered rot on their vines that morning. I learned that this shower did not extend beyond half a mile south of my place, so on Monday morning I drove southward to ascertain if the vineyards were yet safe where there had been no rain. I asked the owner of one of them: "Any sign of rot with you?" "Yes, found the first yesterday morning." "How long since you had any rain?" "Not a drop for three weeks." Visiting various vineyards in the dry region, I found that the rot had appeared simultaneously everywhere, on July 12. It was evident that the wetting of the clusters by actual rain was not alone the cause of the fungus.

I have been so puzzled by the vagaries of this epidemic that I have ceased the endeavor to account for various phenomena exhibited by it, and limit myself to the task of trying to prevent its ravages on general principles.

Years ago, while experimenting with sundry chemicals designed in their application to prevent or cure "the rot," I accidentally noticed a vine, one branch of which was trained beneath the shelter of a projecting cornice, while the other ran over a trellis exposed to the sky. The grapes beneath the cornice were sound; those exposed were rotten.

The next spring I built a board roof 20 inches wide, placed a foot above the fruiting canes, along 100 yards of trellis, through the midst of a vineyard of several thousand vines. The vines thus vertically protected were healthy, but clusters and foliage on laterals, projecting beyond the edge of the roof, rotted and mildewed. The trellises on either side of that protected were badly damaged by disease.

Experiments were tried the same season in protection of separate clusters, by inclosing them in paper bags, in pieces of mosquito-bar, in old stocking-legs, &c. Grapes thus protected ripened uninjured by the *Phoma*.

Finding my board roofing not wide enough, I next year substituted for it an awning made of common cotton sheeting a yard wide, stretched tentwise along parallel wires. Though the tissue of this was permeable by rains, it preserved all beneath it in health. The cloth awning was removed in the autumn and replaced in May. The same strip of sheeting, costing 5 cents per yard, served four years.

In my experience it protects as effectually against rot as does the bagging of the clusters. Why it does so I do not know. It certainly does not exclude access of the germs, with which at times the atmosphere must teem, and which, as I have ascertained, float upward from beneath the vine more frequently than they descend from above. Nor does the awning shed the rain, which, in heavy showers, filters through it quite freely, drenching both foliage and fruit. However, experience

for four years, during which the fruit beneath the awning remained safe in the midst of surrounding devastation, proves its protective efficacy.

While in some respects the paper bag is the more complete protection to the cluster, defending it against attack and defilement of insects, birds, &c., the awning is yet preferable, because, in addition to saving all the fruit, it also protects the foliage from the grape-leaf mildew, *Peronospora viticola*, another distinctively American fungus more dangerous even to viticulture than is the *Phoma*.

When my vineyards have been swept by the *Peronospora*, the foliage blasted as by a conflagration, fruit and canes failing to mature, all on the covered trellises ripen perfectly, the leaves, wherever thus sheltered, being free from mildew. I have seen very curious examples of this protection in the grape leaves situated close beneath the cover of cloth and partly projecting beyond it, that portion only of the leaf which was not covered being destroyed by the *Peronospora*.

There is yet another advantage which may result from the awning above the trellis, if applied early in the spring; it may save the opening buds from destruction of a late frost, and has done so on my vines.

Three years ago I decided to try other devices against the assault of the grape rot. I selected a block of one thousand Concords, from which, through the summer, I had the symptoms of infection removed as fast as they appeared. All the rotted grapes were picked weekly from the clusters, picked up from beneath the trellis, taken away and buried. The leaves wherever spotted by the *Phoma* were also gathered. The benefit of this disinfection was visible at the vintage, but the difference was yet more manifest the next season, when the vines thus cleaned showed an improvement of at least 50 per cent. in their crop.

The second year I also tried burying all the débris of the vineyard late in the spring with a plow, leaving the soil thereafter undisturbed during the summer.

On each side of the trellis I threw a furrow away from it, then raked the dry leaves and rotted grapes which lay beneath the vines into these furrows, then threw the furrow slice back again and plowed the interspaces, careful to bury all the surface deposits completely. After this the vineyard was left uncultivated and it grew a luxuriant crop of weeds, but it yielded a good crop of grapes also.

The good effect of this suppression of germs of the epidemic, when this vineyard was compared with others adjacent not thus treated, was remarkable. I found, however, upon inspecting the rows during the summer that my men who did the raking had been careless, in some places not doing clean work; besides, the rake teeth failed to catch all of the little rotted berries lying on the ground; some of these remained on the surface, and wherever I found most of this débris, there above it, on the vines, were the most rotted grapes. It was plain that the germs of the *Phoma* floated upwards from their nidus on the soil beneath.

This spring, 1885, I resolved to make the work of disinfection more thorough. Substituting hoes for the rakes, I scraped the surface clean, and then buried everything with the plow, making afterwards a final inspection to see that the job was complete.

For comparison I left one block of vines with the rotted grapes from the previous year unburied, but suffered all my vines to remain uncultivated, after the plowing, which was done late in May.

The result fulfilled my expectations, and has rewarded me for my trouble. I have just finished my vintage, harvesting an average of 20 pounds per vine of sound, healthy clusters, free from rot. With the exception of one hundred vines left for experiment (but which were similarly "scraped" with the rest), the rotting grapes were removed as they appeared. In the block where the infection was left unburied there was fully ten times as much rot as elsewhere. Upon the hundred vines from whence the rotting grapes of this season were not removed there was rather more rot than where the vines were kept continuously cleaned of diseased specimens.

In contemplating the feasibility of continuous removal of diseased grapes from a badly-infected vineyard the task seems stupendous. It must be considered, however, that if the remnant of the fruit left by the rot is to be utilized the clusters must be cleaned some time, and it is as cheap to clean them while on the vines as after they are gathered. Besides, if the other means of disinfection above described are carefully employed there will not be so many rotted grapes to pick.

In view of the benefit resulting from their removal it is a job which unquestionably will "pay."

Of all that may be done, however, the complete burial of the sources of infection and the subsequent non-cultivation of the vineyard are the most important.

I saw an interesting exemplification of this during my tour of inspection of vineyards in July last. I first visited a vineyard similarly treated to my own. Rot had begun in it, but not at all seriously; one had to search long to find an infected berry. A fourth of a mile farther on I came to two large vineyards infested with those pestiferous weeds known here as "sand burs." To extirpate these the owners cultivated continuously. The vines were upon stakes, and the cultivator had at that date (July 13) already passed through them four times each way. Rot appeared in these vineyards but two days previous to my visit, but its first attack was almost destructive of the crop. Upon most clusters three-fourths of the berries were specked, and on ten thousand vines that had been well set with fruit there were not enough grapes left to pay for gathering.

A little farther on I came to a vineyard which had been cultivated but once, early in June; the grapes on it were fairly good and healthy.

Not far distant from these I found a neglected vineyard which had been neither plowed nor cultivated this year. All of last year's deposit

of rotted grapes lay undisturbed beneath the vines, which were not even tied up to the stakes. The crop here was badly rotted, but not so much as where the soil had been constantly stirred. Cultivation, especially in dry weather, evidently unburies and sets afloat germs of the disease which are resting on or are buried in the soil.

These observations enable me to account for phenomena of the rot which were before somewhat puzzling.

A neighbor's vineyard, which was cultivated constantly and which rotted persistently, was situated on a slope descending from high, dry sand down to heavier soil, which from its position was naturally more moist. We every year noticed that the rot was worst in the highest part of the vineyard, which seemed paradoxical, because we were disposed to regard the lowest and moistest localities as being naturally favorable to the development of the fungus.

We may now suspect that where the soil was driest and lightest the cultivator most readily stirs up the infecting germs together with the dust. Such was my experience when I cultivated my own vines.

On another occasion when grape rot was exceedingly prevalent, my attention was called to a small vineyard entirely free from rot, while desolation was all around it. It was upon low ground frequently flooded by the rains, abundant that season, the water sometimes standing on it an inch or more in depth for several hours after a hard shower.

That these vines, down in this swamp, should be uninjured by disease while those on the high land around were ruined seemed inexplicable. We may now account for this strange exemption on the plausible supposition that the infecting germs of the *Phoma*, doubtless present in this vineyard as elsewhere, were simply stuck fast in the mud!

The summer of 1885 in this locality has been favorable to the health of the vine. Almost continuous drought, both this season and last, during the critical period of growth has been inimical to the development of the *Phoma*, and the grape crop in consequence has been throughout exceptionally good. Best, however, where the methods of suppression and disinfection described above, have been carefully practiced, and worst where summer cultivation has been persistent.

In unfavorable seasons, when atmospheric heat and humidity prevail, it is doubtful whether in badly-infected districts any of the means of protection here suggested may be effectual, at least not unless they are universally and thoroughly employed. The atmosphere becomes full of the infinitesimal germs of the *Phoma*, which will drift everywhere on the wings of the wind. Hence, at such times the attempt of any single viticulturist to protect his vines from rot, provided he be surrounded by neglected and infected vineyards, will be almost useless.

A few years since, during a hot and humid August, I proved the fact of this general prevalence of the infecting germs by removing from the bags in which they were inclosed perfectly ripe, healthy clusters of white grapes and exposing them upon the roof of an out-house, remote

from the vineyard. In a few days the clusters were spotted by the infection. I found that I could not take grapes from the paper bags which had protected them, pack them, and ship them without endangering their infection even by this trifling exposure. They caught the disease while on the way to market!

Whether the vine may be so nourished by special fertilizers as to fortify it constitutionally against assaults of these destructive fungi is a very interesting question, and many illustrations of the plausibility of this proposition might be adduced. For example, in the cultivation of the grape, in this region at least, we notice that wherever the soil of the vineyard is least fertile and the vines are most unthrifty, there they are most damaged by the depredations of fungi. An enormous and exhausting crop of fruit one year will be apt to invite a fungus eruption the next. I have seen a liberal manuring over a portion of a vineyard maintain that portion in reasonable health while the unfertilized vines adjacent were ravaged by rot and mildew.

The grape diseases in Southern New Jersey themselves afford a striking example in general of the injurious effects of insufficient fertility. The soil here is mainly a deposit of sand and gravel from the waves of the sea and is comparatively sterile. Of two important elements, analysis shows it to possess merely "a trace." These deficiencies are lime and potassa. Under these conditions rot and mildew have, in seasons favorable to their development, swept all before them. In other parts of the State, on a different soil, and where lime and potassa had been liberally applied in fertilization, though rot and mildew were yearly present in the vineyard, they worked but little harm. Thus, for example, in one of the most fertile counties of the State, a viticulturist informed me a few years since that he "had some considerable rot in his vineyard," but he had harvested 19,000 pounds of grapes from 1 acre of Concords.

Contrast this with the yield of an acre of Concords on the land of one of my neighbors. The vines, ten years old, were well set with fruit, but it rotted. I bought the crop; total, 156 pounds!

In one of my vineyards some years ago I estimated, on June 30, that I had 20 pounds per vine set on four thousand vines. Rot began July 5. I finally harvested about 2 pounds per vine. I mention these experiences just to let outsiders know what *Phoma uvicola* is capable of doing.

We may get instruction upon this subject of vital resistance to disease germs from the grape-vine itself. Certain varieties are seen to be especially subject to fungus attacks. Why? It is said "because they are less hardy; innately more liable to disease; the skin of the fruit is too thin; the foliage is not leathery enough," &c. Other varieties are healthy under almost all conditions. Why? "Oh, they are hardy sorts. The skin of the grape is thick, and not easily penetrated by the fun-

gus germ. The foliage is tough, and defended by a peculiar fuzziness, so that the spores of *Peronospora* cannot root in it." But these explanations do not exactly explain. For example, the Ives Seedling is reputed "hardy," and usually is so. I have many vines of this variety, and their fruit has never rotted, though Concords growing among them were badly diseased. Yet, on neighboring farms, growing upon sandy knolls, where the soil might be termed exhausted (if there was originally anything to exhaust), I have seen the Ives Seedling completely riddled by rot. It was evident here that it needed something more than its thick hide and hardiness to save it.

I have a grape which I have named the "Ironclad," derived from a native (apparently a cross between Riparia and Labrusca) growing near the Schuylkill, west of Philadelphia. It is thick-skinned, and, like the Ives, possesses nearly 20 per cent. more of saccharine matter than does the Concord. I have fruited it for ten years, growing among Concords that rotted totally, and it has neither rotted nor mildewed, though its foliage is peculiarly smooth and devoid of down. This season, to check its rampant growth, I allowed it to carry an enormous load of fruit, and growth was also weakened by drought. Under these conditions it has rotted a little and mildewed considerably, indicating that simply overbearing, with defective nutrition at the time, will invite an attack of disease.

From such observations as I have been able to make during the past three years of various experiments over a tolerably widely extended grape-culture, I am much disposed to believe that by giving the vine a full supply of all the elements of nutrition—ammonia, phosphate of lime, potassa, and lime—and by a general adoption of the means of disinfection which I have indicated, we have little to fear from grape rot.

That other grand terror of viticulture, *Peronospora viticola*, or American grape-leaf mildew, may be similarly managed. I have found this season that vines best nourished resisted it best.

There is no benefit from any method of disinfection which I have tried. Sulphur is inefficient, and the burial of the vineyard débris and subsequent non-culture, which are of avail against the *Phoma*, are useless here. When atmospheric conditions favor the development of this pest it spreads like a prairie fire. I have seen the foliage on ten thousand vines completely blasted by mildew within three days after its appearance. Our only defense against *Peronospora* will be in constitutional, prophylactic treatment. Of the value of this I have this season had proof. Mildew struck my vines in September, too late to affect maturing of the fruit. Part of the outside row of one vineyard is beside a piece of ground which had been well fertilized with lime, bone-dust, marl, stable compost, and muriate of potash. This part of the row resisted the mildew, and I can account for it only on the presumption that the health of those vines was secured by the vigor imparted by this extra

nourishment obtained by their roots extending into the rich soil. While there is not a leaf left on the rest of the vineyard this piece of a row yet holds its foliage green at this date, October 20.

I have stated that the cloth awning over the trellis protects against both rot and mildew, though why it does so is not easy to explain. Other examples of protecting influences not less curious may be seen here yearly. In the village of Vineland are many grape-vines grown in the gardens around and among the houses. These vines have no vertical protection, yet they are generally exempt from mildew. Some observers ascribe this immunity to radiation of heat at night from surrounding buildings. Others think it due to shade from the rays of the early morning sun.

On the farm adjoining mine I have noticed a row of grape-vines growing along the west side of and about 10 feet distant from a brick house. That part of the row directly west of the house is never damaged by mildew, but the extension of the row of vines north and south of the building mildews badly. So far as I can judge these vines in the early morning are all equally drenched with dew (which is profuse here in August), but the vines shaded by the house from the east do not get the sun until about 9 o'clock a. m., by which time the dew is mainly dried off by the atmosphere. It is apparent that the presence of the building is in some way protective. Vines deeply planted seem less liable to disease. Those ordinarily rooted from short cuttings, or from layers, and then planted at the usual depth of, say 6 inches, extend their roots horizontally and do not penetrate far down into the soil. Summer drought affecting this superficial root system will check vigor of growth and disease will follow. Hence a deep mulch of any substance which will restrain evaporation has been found a defense against both rot and mildew. In the most successful vineyard which I have seen the vines were planted deeply. Holes, 9 feet apart each way, were dug 4 feet in diameter and 3 feet deep. The vines, one-year-old rooted cuttings, were set at the north side of the bottom of these holes. The roots were covered with 2 or 3 inches of soil, and then a sprinkle of fine bone-dust, say a pint, was worked in over the entire bottom of the hole. This was done in early spring. When growth began, this soil in the bottom of the holes soon was matted with a luxuriant growth of grass and weeds. The vine as it grew was trained up toward the top of the hole; another dose of bone-dust was scattered over the vegetation beneath, which was then buried beneath 6 inches of soil. In a few weeks another growth had developed; the vine was trained farther upwards, and the hole filled with another 6 inches of soil, until by autumn these successive fillings of bone-dust and soil had brought the holes full up to the general level of the vineyard, and the vines were well grown above the surface. Here was formed for these vines a root system reaching nearly 4 feet beneath the top of the ground, twice the depth of the average rooting of our vineyards. The vineyard bore last year its first full crop, and

this season the crop might be termed more than full. Clusters and berries, extra large and numerous, growth of vines rampant, regardless apparently of a sixty days' drought which pinched adjacent vineyards; there was scarcely a sign of mildew, the vines maturing perfectly an enormous load of fruit, and holding their foliage green until it was killed by frost. They gave convincing proof that this method of founding a vineyard, though seemingly troublesome and expensive, "will pay."

Of course, for planting grape-vines for profit, selections should be made of those varieties which have shown themselves most vigorous and hardy. There are favored localities where the more delicate sorts will succeed, but over the general expanse of our country we must grow hardy grapes to make grape-culture practicable as a business.

Appendix C.

THE PREVENTION OF MILDEW—RESULTS OF EXPERIMENTS WITH VARIOUS FUNGICIDES IN FRENCH AND ITALIAN VINEYARDS IN 1885.

These articles, with one exception, are from *Bulletin de la Société centrale d'Agriculture et des Comices agricoles du Département de l'Hérault*, janvier, février et mars, 1886. Montpellier. Grollier et fils.

Owing to the difficulty of giving exact equivalents, the metric system has been retained. The approximate English equivalents of the weights and measures referred to are here given :

One meter = 39.37 inches. To find the value in inches of one decimeter, centimeter, or millimeter, remove the decimal point, respectively, one, two, or three places to the left.

One gram = 15.438 grains troy. To find the value in grains troy of one decigram, centigram, or milligram, remove the decimal point, respectively, one, two, or three places to the left. One kilogram or kilo = 2 pounds 3 ounces 4.4 + drams avoirdupois.

One liter = 1.76 pints ; one centiliter is 0.01 liter ; one hectoliter = 22 gallons.

One are = 119.60 + square yards ; one hectare = 2.47 + acres.

One franc = 18.6 cents ; one centime is one one-hundredth of one franc, or about 2 mills.

To convert degrees Centigrade to Fahrenheit multiply the number of degrees by 9, divide the product by 5, and to the quotient add 32°.

9449 G V——5

I.—NOTE ON THE USE OF ALKALINE POLYSULPHIDES FOR THE MILDEW.

By M. le Vte. Amaury de Montlaur, Engineer.

[Presented to the Agricultural Society of Hérault, November 9, 1885.]

Among the agents for trial, sulphur is the one whose employment first occurred to all. But if flowers of sulphur be efficent against the *Oïdium*, it has shown itself to be without sensible influence on the mildew, the rapid propagation of which far exceeds the transformation of the sulphur into sulphurous acid, the only condition in which it acts on fungi.

I thought next of precipitated sulphur, which is produced in several chemical reactions in so fine a state that it passes through filter-papers, and the rapid oxidation of which I have easily verified.

But it was evident that if one wished to profit by the advantages of this physical state of sulphur, it must be produced on the leaf itself, where it is to be oxidized. Moreover, among the available reactions, the only practical one was the oxidation of the polysulphurets in solution. I was therefore led to "*throw upon the plant a dilute solution of liver of sulphur* (*penta-sulphuret of potassa*) *by means of an atomizer.*"

This body is found in commerce at a low price, and oxidizes more easily than the corresponding sodium compound.

When we expose to the action of the air a surface covered with a one per cent. solution of liver of sulphur, the latter is changed instantly. A deposit of sulphur-precipitate takes place, and at the same time the hyposulphite is formed and remains in solution. If we remove the sulphur we find that the hyposulphite itself oxidizes rapidly in the presence of porous bodies. As the sulphur produced is transformed into sulphurous acid, almost all of the sulphur in the penta-sulphuret is utilized quite rapidly. After some hours a cloth impregnated with this precipitated sulphur contains scarcely any sulphur, except in the form of sulphurous acid.

These, then, are the advantages of my method: (1) The rapid production and almost complete utilization of sulphurous acid; (2) the presence of water, which facilitates the action of the gas upon the fungus.

These are the facts which led me to make some experiments, the last and most conclusive of which are presented herewith.

Experiments.—In the month of May last a vineyard of 10 ares of the Jacquez variety, belonging to the steward of the estate, was attacked by mildew. I treated it by my method the 23d of May. I visited the vineyard the 31st; the disease had disappeared; being taken at its beginning, it had done slight injury and had stopped.

The cure could be attributed only to the remedy or to a change of weather. Now, the weather was as bad after the treatment as before. In fact, the mean humidity of eight days preceding the treatment (the period during which the mildew developed) was 54, with a maximum of 71. After the treatment, from the 24th to the 31st, the mean was the same, and there was a notable maximum the 27th of May.

In the month of July, in cloudy weather with frequent fogs, the mildew soon appears. On the 14th I was informed that it had broken out in the plain of the Clotte, where we had a vineyard of 10 hectares by itself, on low alluvial soil, between the hill and the railroad embankment.

The disease appeared in a hectare of Jacquez six years old, very handsome, with a luxuriant vegetation. My atomizer, of a bad pattern, was then broken, and I could not make the application until the 18th. The mildew was attacking already the first rows of Aramons, grafted on Jacquez and Riparia, and surrounding the old ungrafted (?) Jacquez (*Jacquez francs de pieds*). Eight days later the disease had made no progress. The leaves, which were severely attacked, had indeed dried up, but not another row had been touched. The result was so evident that I did not make a second treatment, as was my intention.

Here, again, the weather had remained favorable to the mildew, the mean humidity being 56 for the second half of July, as for the first; continuous damp weather, with persistent fogs in this inclosed valley. As hygrometric maxima we had 82 and 95 the 19th and 29th of July.

During this weather the disease made progress in the vineyards of all my neighbors, while the vines treated in May, and situated very favorably for the growth of the mildew, showed no sign of attack.

Finally, during the last half of August, there was a violent recrudescence all through the country, except in the vineyards treated. These remained uninjured.

Mode of operating.—The following is the result of my experiments as to method of procedure: It is best to use the Riley spraying machine * mounted upon a reed 1 meter long, communicating by a hard-rubber tube about 2 meters long, with a small pump mounted on a covered cask, which contains the solution, and holds about ten liters.

The solution is easily made by dissolving one kilo of the substance in several liters of boiling water, and then diluting with cold water to a volume of one hundred liters. It should be filtered through a cloth as rapidly as possible.

* For figures and descriptions of spraying machines see *Fourth Report of the U. S. Entomological Commission; Cotton Worm and Boll Worm.* Govt. press, 1885.

Two men are required to work the apparatus; one introduces the atomizer into the midst of the main stems, throwing the spray vertically, so as to reach the lower surface of the leaves, and facilitating the operation by raising the branches with his left hand.

The other operator works the pump and carries the cask slung over his shoulder, steadying it with the other hand, because it is more convenient to carry it so than to place it on the ground and try to hold it by means of the foot-board with which these instruments are provided.

It took these two men four hours to treat the hectare of Jacquez mentioned above, using two hundred liters of liquid. We have, therefore, the maximum cost of the process, for, in general, less time and material will be necessary. Accordingly, 2 francs' worth of material and eight hours of labor constitute the maximum expense.

Liver of sulphur costs 1 franc per kilo retail, and 70 francs per 100 kilos.

Observations.—The solution should never be prepared in advance, for it changes rapidly; and the substance should be kept in the tin boxes in which it comes, in all cases secure from any moisture.

The spraying should be done by preference in the early morning or at sunset, for the evaporation being less active, the liquid does not dry up until the chemical reaction has taken place. I have never worked at any other time.

Finally, it is quite evident that if we act as soon as the disease appears, when there are only a few leaves affected, the arrest of the scourge will be much more rapid; the cure more certain. If, on the contrary, the fungus has invaded the entire vineyard, it is probable that a single treatment will not suffice.

As for me, I think we ought always to be ready to act immediately, and that the workmen should know how to recognize the mildew and should at once give notice to the proper person.

Preventive treatments.—In the month of May last I also treated a vineyard containing about 3 hectares of Aramons grafted on Riparias, situated on the shore of the Vidourle. Although late in putting forth and having yet only a few leaves, this vineyard was already attacked by mildew.

The treatment was given immediately, and the disease did not reappear.

From this fact and those cited above, I infer the efficacy of preventive treatments which forestall the violence of an epidemic by destroying the fungus germs which are on the plant and render an invasion of mildew less severe when they do not put a stop to it.

It is the suddenness of the attack, the rapid extension of the fungus, which makes our struggle against it so difficult.

Moreover, I cite facts only, and on this score I ought to add the following, which has its economic importance.

The vineyards treated in the spring have had neither *Oïdium* nor *Erineum;** this latter, which was greatly injuring the vineyards treated in July, disappeared after the treatment. This fact is not to be wondered at, the remedy which acts upon the fungus which is most difficult to destroy ought evidently to succeed with those the development of which is stopped by ordinary sulphur.

In the present note I give only some facts, chemical or viticultural experiments which have been carried out on a large scale, and not theories and suppositions based upon trials in a garden.

I am personally so well convinced that I intend to employ this method exclusively on my entire vineyard of 82 hectares [202 acres], and I shall be happy if many agriculturists come to assist in my treatments next spring, and to aid me, by their advice and criticism, in perfecting the method by means of polysulphurets.

*The *Erineum* is not a fungus, but is an abnormal growth of the leaf, caused by the presence of gall-mites.—Tr.

II.—THE PERONOSPORA OVERCOME BY HYDRATE OF LIME.

By M. G. B. Cerletti, *Director of the Revue de Viticulture et d'Œnologie Italienne.*

[*Messager Agricole*, October 10, 1885.]

Five years have passed since we announced the appearance of *Peronospora viticola* upon the hills of Conegliano. Since then we have followed with anxiety the announcements of contemporary or later invasions of this fungus in several localities of Upper or Middle Italy, where they have caused more or less considerable ravages.

We are happy to state once more from Conegliano that one can see here entire hectares of vines in which the *Peronospora* has been met and vanquished. It now remains for all viticulturists interested to demonstrate that the results obtained in this locality will be the same in other regions and each year.

The group of substances to which seekers of remedies for the *Peronospora* have directed most attention is that of the alkalies, in the form of hydrate or carbonate. At the end of 1883 the hydrates of soda and lime and the carbonate of soda were stated to be efficacious; the results, however, were neither complete that year nor in 1884, because (as is well established to-day) the application of these solutions was not made at suitable times nor in doses as abundant and as often repeated as was necessary.

Some weeks later M. Rho, director of the Agri-horticultural School of Udine, recommended milk of lime to viticulturists, because at the close of last year he had observed that two vines of *Refosco*, already having a good third of their leaves yellow and burned, had budded anew some days after being treated by the milk of lime. No great importance was attached to the result thus announced, because, whenever for any reason the vine has prematurely lost many of its leaves, a new growth takes place without the use of milk of lime; and, besides, this new growth is not to be desired, because it necessitates a premature consumption of materials which ought to serve for the production of fruit the following year.

Happily, while the several experiments recommended by two successive circulars of the minister of agriculture were made either at the School of Viticulture or on the estates of several proprietors in the

vicinity of Conegliano, the method extolled by M. Rho was tried at the same time on a large area and in a very complete manner.

The preceding autumn the two brothers Bellussi, having observed that some varieties treated with the *hydrate* or milk of lime had resisted the *Peronospora* much better, resolved to treat their whole vineyard this year, one row with milk of lime and another with sulphur. Let us note that they operated upon several hectares and, that, although attached to trees, the rows of vines had a great number of transverse branches, which formed a veritable net-work upon the soil. In passing we may state that this system of pruning would not be approved by those who desire a long and constant production.

In the month of May, by means of a box placed on wheels and by fans (?) (*ventilateurs*), the brothers Bellussi began to sprinkle a part of the rows of vines abundantly with milk of lime (2–3 parts of lime to 100 of water). They repeated this operation five or six times, allowing sixteen days for going over the domain.

The *Peronospora* having appeared only in the month of May from the seashore to the hills, wrought its principal ravages upon the plain where the fields of MM. Bellussi are situated, and it is there that some very remarkable differences may be observed:

1. On the small number of vines which were treated with the milk of lime only once this year, the preservation of the leaves which developed in spring is greater than on the vines simply sulphured. The portions of the leaves which already contained the *Peronospora* are atrophied, but the disease has made no more progress, the rest of the leaf, as Professor Cuboni has shown, remaining green and perfectly capable of nourishing the vine.

2. In the greater number of rows of vines the treatment with milk of lime began in the month of May and was repeated several times, and there the preservation of all the leaves of spring-time is perfect. No trace of *Peronospora* is to be seen, although all the intermediate rows of vines, treated only with sulphur, have already lost two-thirds of their leaves by this mildew, and are in many places in contact with the lime-sprinkled leaves. If there are traces of *Peronospora* upon the vines treated with the lime, it is only upon some very high branches which the sprinkling could not reach. The leaves treated are deep green, they are broader and larger than the others, better nourished, and their peduncles begin to redden, which indicates an excellent alimentation. The grapes are not very plentiful, but are healthy and well nourished; the branches are better than those of the sulphured rows, but on account of the too abundant and long growth, of which we have already spoken, they are not very fine.

3. Finally we come to the vines which were treated the year before, and which have also been treated several times this year. These vines not only retain their foliage in good condition, but also bear a greater quantity of grapes, and their branches are larger and better ripened than in

the preceding case, which proves that the better alimentation of last year has sufficed to give finer branches and a greater quantity of fruit.

In none of the three cases just examined did those new shoots form, which we must consider as injurious, since they are developed at the expense of the future fructification.

It is clearly apparent from these observations that repeated sprinklings of milk of lime will constitute a preventive remedy for *Peronospora*. The part of the leaf which is already attacked by this fungus will not be healed, but even upon that leaf the disease will spread no more; so that, for the diligent viticulturist, we may say that the remedy is efficient, practical, and specific. It can be procured anywhere, and its low price places it within the reach of all.

The milk of lime has shown itself equally efficient against the *Oïdium* and a series of other fungi which attack the living supports of the vine and the fruit trees in the midst of vineyards; so that from an economical point of view the mixture would be preferable, because it will suffice to begin with a sulphuring to prevent the *Oïdium*, and then to continue with aspersions of milk of lime to preserve the vineyard from the *Peronospora* and the *Oïdium*. It is possible that experience will show later that we can omit this first sulphuring.

Any one can verify these facts, either in the fields of MM. Bellussi or in several other localities where the hydrate or milk of lime has been used.

Two questions of less importance still remain to be studied. The mode of sprinkling used in the experiments which we have mentioned is too primitive and is not applicable in all vineyards or upon the hills. The irrigation pump and the "hydronette" pump, which have been used in numerous experiments, ought to be replaced by larger and more powerful instruments or pumps, which do not become clogged, and which are able to throw a much greater mass of liquid.

The second question has reference to the inconvenience already foreseen in 1883, which is that at the time of the vintage a part of the grapes will be soiled by lime. Now, the lime, by neutralizing the slight natural acidity of the wine, might change its flavor a little too much, and sometimes even prevent the ordinary or alcoholic fermentation.

But a way of guarding against this trouble has been discovered. It suffices to put aside the grapes which have retained the lime and to wash them in pure or slightly acidulated water, as we have already explained in detail in this review, year 1882, page 582, when it was necessary to specify how to make wine from grapes soiled with mud after the inundations which had taken place that year.

It is unnecessary to observe that, in normal conditions, the application of the lime ought to be made in the last days of May, or perhaps from the first of June to the beginning of August. There is, therefore, before the arrival of the vintage a certain lapse of time, during which much of the lime is washed off by the rain or shaken off by the wind.

It now remains for interested persons to repeat the experiments. Let those who have so far only traces of *Peronospora* (though ordinarily the remedy should be applied before the disease appears) at once make copious sprinklings of milk of lime, and even this year they can test its effects; and, by retarding the fall of the leaves, they will obtain branches which are better nourished and which, in consequence, will be more fruitful next year.

We will close this note by declaring that persons will be convinced of the efficacy of the remedy by going to verify its good effects on the spot much more than by the best arguments. We think, therefore, that many of those whom occasion or duty may call to give advice in the journals and in associations or agricultural societies, and all those who have a great personal interest in assuring themselves of the reality of the good effects obtained by the use of the milk of lime, should hasten to see the experiments of MM. Bellussi. This will be the best means of disseminating the knowledge of this preventive remedy, and then we shall not see a repetition of what happened after the discovery of sulphur for *Oïdium*. It was only after four years in one country and ten years in another that sulphurings were adopted in ordinary practice, because where sulphur had been employed very few persons went to verify the results obtained, and because then people were little concerned about calling the attention of those interested to the experiments, although they were made on quite a large scale and with results which could not be disputed.

CONEGLIANO, *August* 25, 1885.

III.—SOME ADDITIONAL REMARKS ON LIME AS A REMEDY FOR PERONOSPORA.

By M. G. B. Cerletti.

[*Messager Agricole*, October 10, 1885.]

In the last number of this review we stated that the result of experiments undertaken by several persons to find a remedy for the *Peronospora* could be seen only along the seashore and on the plain at a distance from the hills. In the fortnight which has since elapsed the parasite, favored by frequent rains, has continued its march, reached the foot of the hills, and even invaded, more or less severely, the greater part of the vineyards on these hills, as the characteristic drying and the premature fall of the leaves bear witness.

In this recently-invaded zone are found the vineyards of two estates which serve for the instruction of the pupils of the Royal School of Viticulture. In a vineyard of *Italian Riesling*, the vines of which are planted at a distance of 1.4 by 1 meter, nine plots had been marked off in May of the preceding year and placed in like conditions, some containing 100, others 75 vines. Each plot was isolated from its neighbor by three rows of vines left without treatment, to serve for control experiments, and, at the same time, to prevent the substance applied to one plot from influencing other rows treated in a different manner. The following substances were each used several times upon the vine-plots:

1. Sulphate of iron mixed with plaster, in the proportion of 1 to 4.
2. Sulphate of copper in powder.
3. Flowers of sulphur.
4. Mixture of sulphur, plaster, and sulphate of iron.
5. Phenic acid in solution, diluted with soap-suds and glycerine.
6. Hydrate of lime.
7. Unleached ashes and hydrate of lime in equal proportions.
8. Solution of hydrate of soda, 7 parts to 1,000.
9. Crude sulphur from Altavilla Irpina.

The powders were applied by means of the Carelli bellows; the solutions, by means of the sprayer or small irrigation pump of the Wine Supply Company of Milan.

For some days the result has been quite evident. The 100 vines treated with hydrate of lime have kept their leaves intact, while the

other plots show only slight differences, whether they are compared with each other or with the parts which have received no treatment. On August 25, to show the different conditions, the leaves of 25 vines which commenced to have the *Peronospora* were removed from each plot and weighed separately; but the comparison of these weighings gave no decisive result.

After the experiment which succeeded so well with the brothers Bellussi, new applications of hydrate of lime were made upon four rows of *Pinot-franc*, containing 268 vines; upon sixteen rows of Bordeaux *Cabernets*, containing 1,200 vines; and upon three rows of *Raboso Veronese*, containing 313 vines; a portion of the same plots were only sulphured. The first application was made the 22d of August and repeated again twice after the rains; the anticipated result did not keep us waiting, although the application was tardily made; the vines treated with lime preserved almost all their leaves, while those not treated lost them speedily.

These applications have given an opportunity to try various spraying instruments and several pumps. We can say that the technical question of application presents no difficulty, but from an economical standpoint there is still something to be learned; the pumps we have used cost too much, and we are looking for other more economical patterns.

In the vicinity of Conegliano, the experiments have been repeated by several persons with good results; at least in those localities where, at the time of the application of the milk of lime, the disease was only just beginning. Professor Cuboni writes that he has obtained excellent results in an experiment made near Lac-Majeur.

The good results obtained by the brothers Bellussi become more apparent every day. The vines not treated with the lime have lost almost all their leaves. The branches (*Raboso di Piave*) have remained small, the berries are only half developed, and there are more green ones than colored. It is not so on the vines treated with the milk of lime. These still keep all their leaves, and the grapes on the well-developed bunches are large and already entirely black. More than six hundred persons have signed the visitors' register, and in this number are not included the cultivators brought by proprietors or by managers of great estates in order to verify these excellent results themselves. Nothing was more instructive than the sight of this vineyard. The delegate of a foreign agricultural society having visited the domain of MM. Bellussi and returned to his own country, came again some days later with a photographic apparatus, because he found speech was not enough to enable his countrymen to judge of the effects obtained, or to produce the conviction begotten of sight.

We will close by stating that according to our calculations the effects of this treatment will still be visible for a month. At the School of Viticulture they can also show to visitors different methods of application of the milk of lime.

IV.—ACCOUNT OF THE VISIT OF PROFESSOR DEHÉRAIN TO THE ITALIAN VINEYARDS TREATED WITH MILK OF LIME AS A REMEDY FOR PERONOSPORA.

"Immediately upon my arrival at the school of Conegliano," said Professor Dehérain, "the conversation turned upon the ravages the *Peronospora* had caused that year in Northern Italy. Without seeing, one would never believe the disease had reached such intensity. From the Italian lakes to Milan, from Milan to Venice, and from Conegliano to Bologna all the vines I saw were more or less injured. The vines here extend from tree to tree, following the old method in use in Italy since Roman times, a method which does not appear to have varied since the days of Virgil; and in passing by rapidly on the railroad I could see that they were completely stripped of foliage.

"Instead of leafy branches forming a band of verdure between the trees which support them we see only denuded branches still bearing a few leaves and greenish clusters which will not ripen.

"At the school of Conegliano I was able to follow things more closely. But for the appearance of this scourge the harvest would have been good, because the vines are covered with grapes which in many varieties are still far from maturity. They have, however, occasionally reached their normal size, but the amount of sugar is considerably diminished and their taste is harsh, instead of being sweet and agreeable.

"Moreover, all the varieties are by no means attacked with the same energy; while some resist quite well, others are completely stripped, not retaining a single leaf. The grapes from vines that are injured are not fit for the manufacture of wine, but only for a 'piquette' of little value.

"For several years past the disease has prevailed in Italy as in France and in Algiers; but it seems never to have appeared before with the intensity it has shown this year.

"Already many different remedies for this new enemy have been tried. It seemed probable that the *Peronospora*, like the *Oïdium*, could be vanquished by the application of flowers of sulphur, but it has not yielded to it in the least, and this remedy is of indifferent value; fortunately, however, it is not so with milk of lime.

"Some information on this subject had been given by Mr. Rho, of Udine, but the decisive results were furnished by two viticulturists near Conegliano, the brothers Bellussi. It was proposed that I should go and see their experiments, and I consented very willingly. Before we went to Tezza, where the treatments had been made, I was shown the results of a treatment at Conegliano, in the experimental field of the school itself, which was made as late as the 20th of August, when the leaves were already attacked. The application of the milk of lime had entirely stopped the ravages of the *Peronospora*, and, while the vines kept for comparison were almost stripped of their leaves, those which had been sprinkled with milk of lime had retained their leaves; some previously attacked had become yellow and curled on the edges, but remaining adherent to the plant, they had been able to nourish the grapes which were then ripe, while the green color of the bunches not treated showed that ripening would not take place.

"If I had had under my eyes only the results at the school of Conegliano I might still have doubted the efficacy of the remedy, the difference, although very evident, not being absolutely conclusive. For this reason, that I might be fully enlightened, Messrs. Cuboni and Comboni had desired to show me the experiments of the brothers Bellussi.

"The vines upon which the experiments were made are supported by two parallel rows of trees, and the foliage-covered vine branches extend in cradle form from one row to another. It often happens that a vine-root sends one of its branches to the right and the other to the left. Now the experiment was conducted in the following manner: One of the rows was treated with lime and the other with sulphur.

"The treatments begun in the month of May were repeated five or six different times—as often as the rains washed the carbonate of lime from the leaves. The milk of lime contained 2 to 3 per cent. of alkali.

"The result obtained is wonderful; while the vines which were simply sulphured are stripped, and the bunches, still bearing a large number of green berries, hang upon long branches entirely destitute of leaves, the vines treated with lime are well-covered with leaves and show a luxuriant vegetation, the effect of which is so much the more odd in that the lime-covered leaves are perfectly white; the grapes are abundant and fully ripened.

"From a practical standpoint, this experiment is absolutely conclusive. The brothers Bellussi have certainly rendered a signal service to viticulture in venturing to spray the vines with milk of lime, which was quite concentrated and caustic, since the liquid certainly contained two to three parts of caustic lime in 100. But to the question, Will the operation succeed equally well on all varieties? I cannot reply intelligently. I believe the experiment will be repeated next season in a great number of localities, and if the results, which I have myself seen, are confirmed, we may consider the *Peronospora* vanquished by lime, as the *Oïdium* has been by sulphur.

"The results obtained at Tezza are so striking that they compel belief, so much the more because, as I have said, it often happened that a vine had one branch treated with lime and the other with sulphur, and, while the sulphured branch is now destitute of leaves, the one that received the lime has kept them all.

"From a theoretical point of view, it is very curious to find that the leaf, covered with lime which is rapidly carbonated, has retained its fine green color under this calcareous crust—as a washing for some moments serves to make apparent; the rays of light act through this white crust, and Mr. Cuboni has been able to show that starch occurs in the sun-exposed, lime-covered leaves the same as in the normal leaves.

"The operation of liming presents no difficulty. The apparatus employed are already numerous; a small hand-pump, drawing the lime fluid from a bucket carried by a man, is operated by a second workman, who directs the milk of lime upon the vines; the leaves are washed and appear not to be covered, but the dissolved lime which covers them changes very rapidly into carbonate of lime and they become white. I am persuaded that the discovery of the brothers Bellussi will have the happiest influence in the arrest of this destructive malady, which this year has caused losses amounting to tens of millions of francs."

V.—A REMEDY FOR THE MILDEW.

By M. le Vte de VERGNETTE-LAMOTTE,
President of the Committee of Agriculture of Beaune, Corresponding Member of the Institute.

In the first days of October, on the plains of Beaune, I ran across three small plots of vines which, in the midst of a vineyard entirely stripped of its leaves, presented the most rich and luxuriant vegetation; the wood was well-ripened and in the vintage the grapes gathered were sound and perfectly ripe. These plots belonged to a vine-dresser of the hamlet of Gigny, who, in the month of August, had treated them with a powder of his own invention, made in the winter of 1884–'85.

He used it immediately after the first attacks of the mildew, and had recourse to only one application.

Knowing the action of sulphated stakes on mildewed vines, it occurred to this vine-dresser, Louis Podechard, to treat his vines with quicklime, slaked by means of a solution of sulphate of copper. To prevent the flowing of the liquid, he surrounded the floor, which received the lime, with a ring of unleached ashes; twenty-four hours afterward he added pulverized sulphur to the lime, and mixed this powder with care. It was finally passed through a coarse sieve.

The double advantage of this preparation is (1) *that it gives the copper in a very finely divided and insoluble state, and* (2) *that its use requires no transportation of water into the vineyard.*

With the sulphuring box of the South, this powder produces a thick cloud of dust which settles on the foliage of the vine, as sulphur does in the treatment of the *Oïdium*.

The density of this powder is 0.65 to 0.70.

In testing this new product for copper, I discovered that in its preparation the product undergoes double decompositions, and that finally the copper takes the form of insoluble compounds.

We may also hope that this product will take the place of the sulphur treatment for vines attacked by the *Oïdium*, successfully combating both diseases at the same time; nor do we question but that in the potato rot its employment will give the best results; it has been already employed with the greatest success in the fungus diseases of the pear.

The materials that enter into the composition of the powder are in the proportions of:

	Kilos.
Quicklime	100
Sulphate of copper	*20
Sulphur	10
Wood ashes	15
Water	†50

In the manufacture of the powder a large part of the water disappears; but since the result of the operation gives a weight of about 166 kilos we see that the water absorbed still forms a considerable portion.

Let us now consider the net cost of this product. It requires:

	Francs.
100 kilos of lime, at 2 francs per 100 kilos	2.00
20 kilos of sulphate of copper, at 70	14.00
10 kilos of sulphur, at 17	1.70
15 kilos of ashes, at 5	.75
50 kilos of water	.00
	18.45

These 18.45 francs give 166 kilos of powder. The net cost of 100 kilos is, therefore, 11.1 francs; and as 150 kilos are more than sufficient for the treatment of one hectare, the expense of this treatment, including the cost of labor which we may estimate at 6 francs (a woman, in nine hours, can treat one-half hectare), will amount to a total of 22 francs and 65 cent. [about $1.80 per acre]. All the viticulturists of the country have verified the very beneficial effects of this fungicidal powder; and it is our firm conviction that, in the history of mildew, the name of Louis Podechard will be as well known as was that of Raclet, the vine-dresser of Beaujolais, after his discovery of scalding (?) (*l'échaudage*). —(*Communication made October* 31, 1885, *to the Committee of Agriculture of Beaune.*)

N. B. —As a result of numerous experiments, the manufacture of this powder has been modified by MM. de Vergnette, father and son, who, by the process named hereafter, have arrived at a very simple method of working, and one that gives good results, as shown by a recent analysis made at the School of Agriculture at Montpellier:

Have the quicklime entirely slacked in the air.

Take 100 kilograms of this lime, which has first been passed through a coarse sieve to remove foreign bodies or "pigeons."

With 5 kilograms of this lime and 15 kilograms of water, make a clear milk of lime.

* To dissolve 20 kilos of sulphate of copper in 50 kilos of water we warm the water slightly and use the solution as soon as it has reached the temperature of the air. It would seem, however, that the amount of sulphate of copper might be reduced and still yield a cold saturated solution.

† According as the lime is more or less air-slacked, the amount of water may vary from 40 to 50 liters.

Dissolve 10 kilograms of sulphate of copper (the purest possible) in 30 kilograms of warm water.

Let the solution cool to 20°–25° C. [68°–77° F.]

Mix this solution with the milk of lime and stir well.

The 95 kilograms of lime being spread out on hard ground, preferably on stone flagging or concrete, to a depth of 20 centimeters, and the mixed liquid being placed in a pump watering-pot with very large holes, one workman sprinkles the lime while another stirs and mixes it by means of an iron rake with very long teeth, then shovels it over and makes it into a heap.

Let this powder, which is only moist, dry for some days; calender or roll it after complete desiccation; sift through a fine sieve and bag it.

Experience seeming to prove that very small quantities of sulphate of copper suffice to render certain the efficacy of the powder, we expect to employ this composition in doses much smaller yet than those indicated above. In consequence of this modification the mode of preparation just described will not be changed at all.

By reducing the quantity of sulphate of copper something will be saved, and the harmlessness of the treatment will be only the more certain.

However that may be, even under the present conditions, the net cost of 100 kilograms of this powder, which is enough for the treatment of one hectare, does not exceed 7 francs, to wit., 2 francs for the lime and 5 francs for the sulphate of copper.—*Vte. Ch. de V., Montpellier, February* 24, 1886.

VI.—REPORT TO THE MINISTER OF AGRICULTURE ON THE TREATMENT OF MILDEW IN MÉDOC.

By M. PRILLIEUX, *Inspector General of Agricultural Instruction.*

PARIS, *October* 22, 1885.

The MINISTER:

SIR: For a long time it has been the custom in certain parts of Médoc, especially in the vicinity of Margaux, St. Julian, and Pauillac, to sprinkle the vines that skirt the railroads with milk of lime, to which is added a salt of copper. Verdigris was formerly employed for this purpose, but, on account of economy, for several years past it has been replaced by sulphate of copper. The purpose of this operation is to prevent children and marauders from picking the ripe grapes which are most easily reached. They are afraid to eat the clusters which hang upon vines spotted with verdigris and discreetly respect them.

In this manner they treat a border from five to ten vines in width.

When the mildew developed in Médoc with considerable severity, it was noticed with astonishment that the borders of the vine-plots, covered with spots of lime and copper, were less severely attacked by the disease than was the middle, which had not undergone the same treatment. Already in 1882 this very unexpected fact was authenticated in the parts of Médoc most violently attacked; but it was especially last year, 1884, that the preservation of the borders, spotted with lime and copper salt, appeared with a striking perspicuity; when, around St. Julian in particular, the disease took an extreme intensity and caused the greatest ravages. While the leaves invaded by the *Peronospora* everywhere dried up and fell prematurely, along the roads they continued green and the grapes ripened.

This year, with the first appearance of the mildew which last year caused such great losses, several proprietors or stewards of vineyards attempted to apply, to the protection of entire vineyards, the method which had seemed to preserve the borders last year. At St. Julian, Pauillac, Margaux, and St. Estèppe, the trials made have fully succeeded, and I am happy to have been able to everywhere verify the complete success of an empirical remedy, which chance discovered, but whose mode of action science will have to study and explain.

The first domains I visited were those of Langoa and of Léoville, near St. Julian, belonging to MM. Barton. The steward, M. D. Jouet, my old pupil at the Agricultural Institute, had kept me constantly informed as to the observations he had previously made there, and also as to the experimental treatments he had instituted there this year.

The mildew appeared in the vineyard on the 10th of July, and they began to treat the vines at this time.

The liquid used by M. Jouet for sprinkling was obtained by dissolving 25 kilos of sulphate of copper in a Bordeaux cask, containing 225 liters of water, and then adding 25 kilos of lime in the form of milk of lime. Other persons have reduced the amount of sulphate of copper to 16 kilos per cask, about 8 to 100 liters [or about 17 pounds to 22 gallons], and have obtained as good a result at a little less expense. In this way there is formed a somewhat thick, bluish-gray, opaque liquid.* It is poured into pots with iron bails. These are carried by the workmen who make the treatment. They sprinkle the vines by means of small twigs of heath, which are plunged into the liquid and shaken right and left upon the leaves, the workmen, in order not to spatter themselves walking backwards, through the rows of vines.

After their passage we see numerous bluish-green spots scattered here and there on the upper surface of the leaves. This treatment suffices to preserve the vines from the mildew, or, at least, to lessen, to a considerable extent, both the multiplication of the *Peronospora*, and the devastations which result therefrom.

From the time of treatment until the 26th of August, the weather this year in Médoc was very warm and dry. In these conditions, the development of the *Peronospora* stopped. On all the vines, treated or not, the parts of the leaves attacked dried up without extending and without bearing fruit. The vegetation of the vine did not in any way suffer from it.

Immediately after August 26, and during the first days of September, storms and copious rains followed each other uninterruptedly. Then the *Peronospora* emerged from the torpid condition in which it had remained during the dry weather, and developed rapidly. Finally, toward mid-September, the disease made fearful progress; not only did the Malbec, Verdot, and white Cabernet, which are very sensitive to the mildew, shed their scorched leaves, but the Cabernet-Sauvignon was also severely attacked (although it is more hardy). Everywhere around St. Julian and Pauillac the vines lost their verdure; the scant foliage which remained on them was burned, and had a brown, earthy color.

After the drought, when the mildew reappeared with intensity, and developed very rapidly on the vines not treated, it also showed itself on the treated vines, but did not spread over them. Around the dried

* The sulphate of copper is entirely decomposed by the lime, and the liquid used for the treatment holds in suspension oxide of copper and plaster, and in solution, only a little lime and plaster.

spots on the leaves which were attacked before the drought, there appeared on the vines treated as well as on those which had not been, a whitish crown of fructiferous filaments, but the spots did not spread much on the former, and no new ones were formed. After the treatment the parasite was still living in the tissue of the leaf, and even produced spores [conidia], but these doubtless did not germinate, and hence they did not spread the disease. The leaves continued to grow, remaining green up to the time of the vintage, and thus securing the complete ripening of the grapes, while the vines not treated were scorched and destitute of leaves.

In the first days of October, when, with M. Jouet, I visited the vineyards of Langoa and Léoville, the boundary line between the parts treated showed at a distance with the utmost plainness. The rows of vines not treated, which were left for comparison in the treated fields; and, inversely, the rows and islets treated, in the midst of plots not treated, struck the eye in a most remarkable way, especially in the plots of Malbec, in which the disease had entirely destroyed the leaves of the untreated vines.

The treatments at Léoville and Langoa were made upon an area of about 9 hectares. The vineyards of Médoc being laid out by the square meter, nearly ninety thousand vines were thus treated in the domain of MM. Barton. It was especially on plots of Malbec that the treatment was tried. In some places these vines were mixed with white Cabernet and Cabernet-Sauvignon.

On the vines treated the bunches ripened much more completely. The Malbec grapes gave a must which by the glycometer indicated 11° to 11°.5 quite uniformly, while the Malbecs from plots not treated gave a must which scarcely reached 9°. A plot of white Cabernet of 1½ hectares gave exactly the same results. The must weighed 11°.5 by the glycometer, while the must from the non-treated white Cabernet scarcely marked 9°. Near Pauillac, at the château Mouton d'Armailhac, M. de Ferran showed me vines that he had treated only between the 15th and 20th of August, which were admirably preserved, even in the midst of fields stripped of leaves by the mildew. As with MM. Barton, the treated vines yielded a must which with the glycometer registered from 2° to 2°.5 more than that of untreated vines of the same variety. The quantity of sulphate of copper employed in the treatment by M. de Ferran was less than at Léoville, being only about 16 kilos per cask of water [225 liters], and the results were as satisfactory.

It was, however, in the domains of M. Johnston, at Beaucaillou in the commune of St. Julian, and at Dauzac, near Margaux, that the treatments were made on the largest scale. At Beaucaillou the results of the operation were somewhat less sharply defined than at Léoville and at Mouton-d'Armailhac, because there the mildew developed with a little less intensity; but at Dauzac the experiment was made on a grand

scale, and under the most convincing circumstances. At Dauzac everything contributed to give the treatment an exceptional importance, not only because it was tried on a larger area than elsewhere (the five plots treated being equal to a total area of 15 hectares) and upon the different varieties of the Médoc, in a locality severely attacked by the disease, but especially because it was directed and studied with care by M. Millardet, the learned professor of the faculty of sciences of Bordeaux, assisted by his eminent colleague, the professor of chemistry of the faculty, M. Gayon. It is to be hoped that the studies of these two scientists will enable us to explain how the treatment acts, and if it cannot kill the mycelium of the *Peronospora* in the leaves attacked, how at least it can prevent the germination of the spores which it continues to produce. This is a question that for the present may be set aside. At this time I propose to set forth only facts of which I have been a witness, and I can state positively that I have nowhere seen the good effects of this treatment more clearly marked than on the estate of M. Johnston, at Dauzac.

Conducted by M. David, the steward of the domain, I verified the excellent results upon plots of different varieties—Malbec, Verdot, Cabernet-franc, and Carmenère. In each instance, in order to show the efficiency of the treatment, M. David had taken pains to keep some rows of untreated vines. An inspection of the domain of Dauzac would convince the most incredulous.

One point appeared to me as especially worthy of mention. Two plots of Malbec did not seem to have been equally protected by the treatment; one had kept the greenness of its foliage much more than the other. M. David was able to give me the explanation, which was that the best preserved plot was treated on the very first appearance of the mildew, while the other was left till the disease had already made some progress. The earlier the treatment the more complete was the preservation.

The liquid employed by M. David for the treatment contains about 8 per cent. of sulphate of copper. The work is done entirely by men, and he estimates the expense at about 50 francs per hectare [$4 per acre]. In this way he has treated 150,000 vines—that is to say, an area of 15 hectares [about 37.5 acres]. He thinks that 50 liters [11 gallons], of the liquid are sufficient for the treatment of 1,000 vines. provided that in sprinkling the vines, we use only small brooms of heather, not large enough to take up a very great quantity of the liquid. In the beginning of the treatment, in some cases, they wastefully used as much as 150 liters of the liquid, because the sprinkling brooms were too large.

In the treatment of some plots, M. David added glue to the ordinary liquid in the proportion of 6 kilos to 800 liters of water; he believes he has thus improved still more the efficiency of the remedy.

At Dauzac as at Léoville, and at Mouton-d'Armailhac, the ripening of the grapes was much more complete in the portions treated than in

the parts not treated. To determine this, the vintages were studied and analyzed by M. Gayon, who will doubtless publish the very interesting results of his researches. At Dauzac they mentioned, as an example, the results he had obtained with the little Verdot, the grapes of which in the plots treated gave, on analysis, 175 grams of sugar, while in the plots not treated the grapes contained only 39 grams. This is without doubt an extreme case, but one which shows clearly the efficacy of the treatment.

At quite a long distance from these vineyards, at St. Estèphe at the château Salle de Pez, belonging to M. Lawton, I finally visited some vines treated with a success not less complete.

The steward of the domain, M. Trossigère, employed for the treatment, which he made in the ordinary way, 8 kilos of sulphate of copper to 100 liters of water, as at Dauzac, adding thereto 15 kilos of lime in 30 liters of water. The results have been excellent; and on reaching the château it is wonderful to see on one side of the road the treated vines covered with verdure, and on the other side the untreated vines of the same variety stripped of leaves.

By this treatement he has very successfully protected even the most tender varieties, such as the Malbec and the white Cabernet. In the domain of Sal de Pez we find a new and most convincing instance of the efficacy of the treatment which has succeeded this year in Médoc wherever it has been tried. But one fact which appears to me interesting to point out is the good result obtained by pure sulphate of copper, *i. e.*, not mixed with lime. Some rows thus treated with a solution containing 8 per cent. of sulphate of copper have given results almost as satisfactory as those which received the ordinary treatment with addition of lime. I wish to mention this fact particularly because it seems to contradict other experiments unsuccessfully made by various persons, and also because it is well to collect all data which may serve to throw light upon the mode of action of the treatment, the efficacy of which is all I propose to establish at present.

At the château de Pez the ordinary treatment was made by women paid at the rate of 75 centimes per day. Although in some places the work might have been done somewhat better, nevertheless, on the whole, it was satisfactory. In conditions similar to those at Pez, M. Trossigère thinks that the cost of treatment ought not to exceed 30 francs per hectare.

To recapitulate, by the facts which I have verified in Médoc, it appears to me established that the sprinkling of vines with a liquid containing about 8 per cent. of sulphate of copper, mixed with a milk of lime, stops the progress of the mildew and permits the affected vine to completely ripen its grapes. This treatment is easy to make and inexpensive. It is to be hoped that next year all vine-growers will try it. The earliest treatments have given the best results.

The critical investigation of the action of the treatment, discovered

by chance, is a very interesting subject for scientific studies; and there is every reason to hope, thanks to the labors undertaken by MM. Millardet and Gayon, that light will be thrown on this subject, which is yet very obscure. Meanwhile, it has given me great pleasure to be able to verify the efficacy of the empirical process which, if the present expectations do not fail, will save French agriculture incalculable riches.

Thanks to the labors of scientific men, and to the efforts and sacrifices of agriculturists, in many respects we no longer despaired of saving vines from the attacks of the phylloxera; but up to this time we have known no remedy for the ravages caused by *Peronospora*, and in the South and Southwest the injuries due to this parasite were so great that vine-growers looked upon the future with alarm.

If I have not been the victim of an illusion all through the excursion I have just made in Médoc, we now have for our protection against the mildew a remedy which is as efficacious as is sulphur in combating the *Oïdium*.

What is more, it does not seem to me impossible that this unexpected remedy may be of service not only to the owners of vineyards, but also to the agriculturists of the North. The *Peronospora* of the vine is a near relative of that of the potato, and there is no improbability in supposing that the remedy which is efficacious for the one may also have a desirable effect on the other. Already I can bring one fact to the support of this hypothesis. At Château Langoa some tomatoes were attacked by a disease which, to all appearance, was due to the development of the *Peronospora* [*Phytophthora*] of the potato, which we know attacks the tomato also. Mr. Jouet treated them like his vines, and he assures me that he also effected their cure.

However isolated this fact may be, it ought to be mentioned so that next year growers of tomatoes, and especially of potatoes, may on the first appearance of the disease try experiments in their fields, analogous to those which have been carried out with so much success this year on the grape-vines in Médoc.

VII.—ON THE DESTRUCTION OF THE MILDEW BY SULPHATE OF COPPER.

By M. A. Perrey.

[From the *Comptes Rendus* of the Academy of Sciences, Paris, October 5, 1885.]

On the 25th of September, 1884, I communicated observations to the Academy which proved the destructive action of sulphate of copper on the mildew. After having shown the immunity procured to young plants by dipping stakes into a copper solution, I took exception to the practical value of this mode of preserving the vine, which is neither applicable to vines not staked, nor sufficient for the protection of those with large arborescence, and is in all cases quite costly. By experiment, I have this year found a method of employing the copper salt which has made its efficacy certain, and permits of its economical employment in all cultivated fields. It consists, by the aid of a spraying machine, in spreading upon the upper surface of the leaves, in the form of a vapor, a solution of crystallized sulphate of copper, 5 parts to 100.

My experiments were carried out under the following conditions: Toward the close of July, or perhaps earlier, the mildew was noticed. Nevertheless when I reached Burgundy, August 8, the vines still had a superb appearance; at rare points only had the action of the mildew been detected, and the proprietors of the vineyards believed they were secure from all danger. But by examining the under surface of the leaves on a great number of apparently uninjured vines, I was enabled to make out the presence of the parasitic fungus, and to detect some characteristic reddish spots.

The sulphate of copper treatment was made in five plots, on the following dates, August 8, 9, 11, 12, 23, 29.

From August 8 to 28 not a drop of rain fell, and the dew did not moisten the leaves once. From August 15 to 22–'3 I could follow the development of the parasite in its slow progress; from the 22d–'3d to the 28th the development made rapid progress. The vines continued, however, to present a general green hue, which began to grow yellow only toward the end of the period. The progress of the mildew was exactly the same on the plots treated and on the surrounding vines. A rainy

period set in August 28. At the close of the first week in September there was a radical change in the appearance of the vineyards in all the region. From their brown color one might now mistake them, at a distance, for plowed fields. The leaves had fallen in great numbers, and those which remained, largely brown-edged, had a dull green center, like leaves detached from the stem and artificially dried.

On September 15 I visited my experimental fields. The first, in the form of an elongated rectangle, was set with Gamai-Mourot six years old. It contained one hectare. A narrow path separated it longitudinally into two portions; to the left was a half hectare not treated; to the right a half hectare treated from the 9th to the 22d of August. The difference in appearance struck one at the first glance: to the left the stocks had kept only a few leaves, which were withered and burned; to the right they had preserved two-thirds of their normal foliage, the injury being almost exclusively near the root of the vine. The leaves, which were spotted upon the margin, remained a brilliant green, and but for the purple patches which are always present at this season upon the leaves of vines of this variety, their appearance was the same on September 13 as at the commencement of the rains.

The second experimental field contained 25 ares set to Mourot. This vineyard, which was remarkably fine at the end of July, had suffered exceptionally by August 12, at which date the treatment was applied to the half most injured. September 13 the part not treated was lost, not a leaf remaining to bring the berries to maturity. The part treated, and the one most diseased on August 12, was indeed not in a flourishing condition, but the vines, stripped below, were still quite green and tolerably well provided with foliage above.

Two other plots, one inclosed in a very old vineyard of Gamai, treated August 8, and the other inclosed in a vineyard of Pinot, layered that winter and treated August 25, showed at a distance by their greenness, and nearer by the abundance of leaves, in marked contrast to the burned and defoliated background of the vineyard.

In a word, before the rains, the mildew made the same progress in all the vineyards, whether treated or not; the rain came on, acting as an indispensable auxiliary to the treatment, and while the vines not treated were defoliated in a few days, the subsequent progress of the mildew on the others was radically arrested by the diffusion of the copper salt.

September 25, the day before the vintage, I made a new visit. The difference in appearance, verified on the 13th, was still more pronounced. The vines not treated had lost the remnant of their leaves, while the vines treated had suffered no appreciable loss, except those of the second plot. But the essential difference between the two classes of vines now rested chiefly in the condition of the wood and berry. On the vines not treated, the wood, surprised by the early fall of the leaves, was not well matured; the shoots of the year, of a clear brown at the base, but still herbaceous for a great part of their length, were some-

times even broken under the weight of the terminal bunches. On the vines treated, the ripening of the wood, improved by three additional weeks of vegetation, gave to the shoots a woody character and a brown color, which extended almost to their extremity.

The advantage to the berry, which was shriveled and easily detached on the vines not treated, but plump and firmly attached to the bunch on the vines treated, at once struck even the inexperienced eye. The vine-dresser estimates, quite exactly, that the saving due to the treatment is, on an average, one-fourth in both quantity and quality; that is to say, a vine treated would yield 4 hectoliters [11 bushels], worth 100 francs, while a vine not treated would yield 3 hectoliters, worth 75 francs. Applied at the beginning of the disease, the treatment would have given, according to the estimate of the vine-dresser, a gain of one-third in quantity and quality. To sum up, my treatment did not entirely prevent injury, because it was applied only after the mildew had begun to develop and was followed by a long period of absolutely dry weather. But it did have a remedial effect, the efficacy of which was made certain by the first rain, and demonstrated in the preservation of the leaves, the ripening of the wood, and the growth and maturing of the berry, in a manner that was more striking in proportion as the disease was more advanced. In Burgundy it will be expedient to apply this treatment from the 1st to the 15th of July. Experience alone will decide whether one treatment will be sufficient, but it appears probable that one is enough.*

As a matter of economy I shall attempt to substitute the sulphate of copper solution for sulphur in the treatment of *Oïdium*. In conclusion, I may add that the greater number of the vineyards in our region have been treated to sulphur this year, and that the sulphuring, applied in the customary way, has not in the least, or not appreciably, checked the encroachment of the mildew.

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* The spraying machine which I have employed is made at Paris, by M. Duffour, and is entirely of red copper, with well-soldered joints, copper being the only metal that resists the action of the copper solution. It is made in a simple and solid manner, and costs 20 francs. It might receive to advantage some modifications, which will be elaborated with a view to the approaching season. With this instrument the treatment of one hectare, planted to 15,000 vigorous vines, consumed less than 100 liters of the solution, and required 45 hours of labor. I give these figures to keep within the limits of the actual results obtained, but with the conviction that the time which suffices to cover the hectare with flowers of sulphur, which is one-half less, will also suffice to cover it with the copper spray; it will only be necessary to give a little wider spread to the jet of the spraying machine.

VIII.—TREATMENT OF MILDEW BY SULPHATE OF COPPER.

Observations made by Mr. MÜNTZ.

[*Journal d'Agriculture Pratique*, November 12, 1885.]

Mr. Hervé Mangon, on the 12th of November, presented a note from Mr. A. Müntz on the treatment of mildew by sulphate of copper.

The observations of Mr. Müntz were made in Dordogne, Gironde, and Lot-et-Garonne, on the four estates possessed by the National Anti-Phylloxera Society. The disease began to show itself in this vineyard toward the middle of July. Immediately, *i. e.*, from July 16–20, a sulphate of copper treatment was applied. A period of very hot weather, coming on at this time, checked the development of the fungus; consequently, no appreciable difference could be observed between the portions treated and those which were not. But the rains at the beginning of September brought on a new invasion of the mildew, much more energetic than the first; the leaves dried up and fell in a few days. It was then that the action of the sulphate of copper became manifest, "all the vine-stocks which were treated in the month of July have kept their leaves; they form oases of verdure in the midst of vineyards entirely stripped; the grapes which they bear have ripened, while those of the vines not treated have been arrested in their development and ripening." Mr. Müntz has found 9.40 parts in 100 of sugar in the must of the vines not treated, and 15.30 parts in 100 in that of the vines treated; the first contained 9.60 per cent. of acid and the second 5.20. The treatment in the month of July consequently preserved the vines from invasion in the month of September. According to Mr. Müntz the treatment was applied in the following manner:

About 25 cubic centimeters of a solution of sulphate of copper (1 part to 10) were distributed upon each vine by means of a small hand-spraying machine. The vines were planted in rows, at a distance of two meters, or at the rate of 5,000 to a hectare. The treatment was given to 1,070 vine-stocks, taken at eight different points in the four estates. The Jurançon variety was selected as being the one most subject to the attacks of the mildew in that region. The cost of this treatment, which was made under conditions very unfavorable to economy, amounted to

only 24.4 francs per hectare. The manual labor, estimated at fifty-nine working hours, represents about 15 francs of this total.

The following observations were made during the progress of the experiment. The too free application of a solution of sulphate of copper may produce red spots on the leaves, but these spots disappear after a few days.

A solution of sulphate of copper, 5 parts in 100, appears to give results almost as advantageous as one of 10 parts in 100.

The additional labor of applying the solution to the lower surface of the leaves is unnecessary.

Young shoots developed after the application of the sulphate of copper are not protected; the ends of the shoots, on which leaves develop after treatment, are entirely stripped.

A treatment made during a high wind gives less satisfactory results.

No copper was found in the wine from the treated vines. The mixture of lime and sulphate of copper gives results which are perhaps even more striking, for in this case the copper remains applied to the leaf in an insoluble form, and is not carried away by the rain. But then there is risk of having copper in the vintage.

According to Mr. Müntz the most economical method of treating vines planted in rows consists in the employment of a small cart, drawn by a horse or a man, the wheels of which set in motion a double bellows communicating with the reservoir holding the solution. The liquid is projected sidewise on both rows at the same time by several atomizing tubes which spray the stocks throughout their height. Under these conditions the cost of treatment would be lowered to 10 francs per hectare.

IX.—TREATMENT OF MILDEW AND ROT.

By M. Millardet, *Professor in the Faculty of Sciences of Bordeaux*

[*Journal d'Agriculture Pratique*, October 8, 1885.]

Since the appearance of the mildew in France (1878), I have not ceased to study *Peronospora viticola* in the hope of discovering a weak point in its development which might enable us to become master of it.

I noticed in the course of my investigations that the summer spores or conidia of this *Peronospora* easily lose their power of germination. This observation, and the failure of all treatments tried up to that time, led me to formulate this conclusion: That a practical treatment of the mildew should aim not to kill the parasite in the leaves which are infected by it, which appears impossible without killing the leaves themselves, but to forestall its development by preventively covering the surface of the leaves with various substances capable of depriving the spores of their vitality, or at least of hindering their germination. Therefore, three years ago I was seeking a substance that would serve the purpose I had outlined, when chance placed it in my hands.

At the close of October, 1882, I had occasion to pass through the vineyard of St. Julian, in Médoc. All along the road I followed, I was not a little surprised to see that the vines still bore leaves, while everywhere else they had long since fallen. There had been mildew there that year, and my first impulse was to attribute the persistence of the leaves along the way to some treatment which had preserved them from the disease. In fact, examination enabled me to ascertain at once that these leaves were covered, in great part, on the upper surface, with a thin, adherent layer of a bluish-white, pulverulent substance.

Arriving at the château Beaucaillou, I questioned the steward, M. Ernest David, who told me that the custom in Médoc is to cover the leaves, at the turning of the grapes, with verdigris or sulphate of copper mixed with lime, to keep off marauders. The latter, seeing the leaves covered with coppery spots, dare not eat the fruit hidden beneath, for fear it may have been contaminated by the same substance.

I called the attention of M. David to the fact of the preservation of the leaves just mentioned, and communicated to him the hope, to which

this observation had given birth, of finding in the salts of copper the basis of the treatment for the mildew. At first M. David raised several objections, but afterward he entered so completely into my ideas, and aided me so efficiently, that I must ascribe to him the best part of the ultimate success.

The following year (1883) I made various trials in my garden, both with the substances named and with others. M. David repeated the most of these experiments at Dauzac, in Médoc, on the estate of M. Nathaniel Johnston, of which he is the steward.

The experiments were continued in 1884, but by an unlucky chance the mildew appeared to so slight an extent in the vineyard where the experiments were made that it was impossible to judge accurately of the value of the various treatments which had been applied.

Nevertheless, as a certain report was noised abroad of the sulphate of copper treatment, I decided to communicate to the Agricultural Society of Gironde the results obtained. May 1, 1885, I published the exact composition of the liquid to be used (based on the trials of M. David), together with instructions relative to both the mode of application and to the most favorable time for treatment.*

After this communication, several large proprietors of Médoc did not hesitate to apply, on a large scale, the treatment which I had extolled.†

M. N. Johnston, to whom I had communicated my ideas in 1882, and who, for two years, had kept pace with the experiments of his steward, M. David, entered into the matter with decision, and he alone had 150,000 vines treated on his two estates of Dauzac and Beaucaillou. Everywhere the results have surpassed my expectations.

At present, October 3, the vines treated have a normal vegetation. The leaves are healthy and of a fine green; the grapes are black and perfectly ripe. On the contrary, the vines not treated present the most miserable appearance. The greater part of the leaves have fallen and the few that remain are half dry; the grapes, still red, can be used to make nothing but "piquette." The contrast is startling. I will add that my colleague, M. Gayon, professor of chemistry in the Faculty of Sciences, kindly consented to examine the musts produced both by the grapes from the vines treated and by those from the vines not treated. He found in the same variety (the Malbec)—

Constituents.	Vines treated (grams per liter).	Vines not treated (grams per liter).
Sugar	177.0	91.8
Acidity, estimated as sulphuric acid	5.1	7.7

* *Annales de la Société d'Agriculture de la Gironde*, 1885, p. 73.

† The author mentions particularly eight estates on which it was tried.—Tr.

The fact that these experiments were conducted as methodically as possible adds still more to their value. In each plot treated may be found, as contrôl evidence, several rows of vines not treated. I will state, moreover, that the treatment was given by preference to the varieties most sensitive to the mildew—the *Malbec*, the *Cabernet-Franc*, and the *Petit-Verdot*—so that its effects on varieties less subject to the disease could be only still more satisfactory. Finally, I will add that this year the disease has shown an exceptional severity.

All these considerations, it appears, sufficiently authorize me to affirm, in the most express manner, the efficacy of the treatment mentioned against a scourge which, up to this time, has baffled all efforts both in Europe and in America; that is, the mildew, properly so called, and the *rot* or mildew of the berry. But more: The close analogies which exist between the *Peronospora* of the vine and that which causes the disease of the potato and of the tomato lead me to hope that henceforth we shall have a real prophylactic for these last affections.

The experiments of this year show with how much reason I insisted, in my communication of May 1, to the Agricultural Society of the Gironde, on applying the treatment preventively; that is, upon the first appearance of the mildew in the vineyard. All who have treated vines which were already somewhat seriously attacked have reaped much less benefit from the operation.

There is a final important point to be considered. In spite of all precautions some drops of the coppery mixture may fall upon the grapes. Will copper be found in the wine? And if found there, may it occur in sufficient quantity to injure the public health?

My colleague, M. Gayon, has promised to assist me in settling this question. A preliminary analysis, made by him, of 800 grams of grapes from treated vines, has not shown copper to an absolute certainty. Researches will be continued in this direction, and I hope soon to be able to submit the results to viticulturists.

[To avoid repetition, the author's account of the preparation and application of this mixture is omitted. See pages 15 and 85 of this Report.]

X.—EFFECTS OF MILDEW ON THE VINE, AND THE INFLUENCE OF EFFICIENT TREATMENT.

By Messrs. MILLARDET and GAYON, *Professors in the Faculty of Sciences of Bordeaux.*

[*Journal d'Agriculture Pratique,* October 29, 1885.]

We already possess important information relative to the influence of mildew on the vegetation of the vine, on the fructification, and on the quality of its products. But, until now, for want of a really efficient treatment, it has been impossible to determine this influence with exactitude; that is to say, by means of the immediate comparison of vines attacked by the scourge with vines perfectly healthy and comparable as to age, soil in which they grow, etc. Thanks to the treatment recently made known by one of us, this gap can now be filled.

The specimens upon which these observations were made, the results of which are given further on, were selected by ourselves scarcely eight days ago [October 2] in the vineyard of the Château Dauzac, in Médoc, of which M. Nathaniel Johnston is proprietor. Whether they belong or not to the plots submitted to the treatment, they represent the average conditions of the vegetation. The vines from which they came were near each other, of the same age, and planted in soils of the same nature, so that the observations resulting from their study are comparable.

The figures which have been added to this note represent two vines of *Cabernet-Sauvignon*, both fifteen years old, and come from two adjacent rows of vines, one of which was treated in the middle of last July, while the other received no treatment. Dug up with care, they were immediately photographed the same size. At the first glance we recognize on one of these vines the disastrous effects of the disease, and on the other the truly marvelous efficacy of the treatment.

This general impression is confirmed still more by the following circumstantial account of the observations, which account gives the relative weight and number of the leaves, branches, grapes, etc., borne by the treated and the untreated vine.

TABLE I.

	Leaves.			Clusters.			Branches.		
	Number.	Total weight.	Average weight.	Number.	Total weight.	Average weight.	Number.	Total weight.	Total length.
		Grams.			*Kilos.*			*Grams.*	*Meters.*
Treated vine	424	290	0.684	18	1.570	0.0877	18	632	14.00
Untreated vine	42	15	0.357	14	0.827	0.0590	13	415	7.64
Difference	382	275	0.327	4	0.743	0.0287	5	217	6.36

The comparative study of the musts furnished by grapes of treated and untreated vines of the same variety gives results no less interesting and exact, especially as the grapes were picked at the same time, in the same vineyard, from vines of the same age.

TABLE II.

Name.	Vines.	Yield in must.	Specific gravity.	Sugar, per liter.	Acidity per liter (estimated as sulphuric acid)
		Per cent.		*Grams.*	*Grams.*
1. Malbec or Côte-Rouge	Treated vines	66.9	1,080	177.0	5.1
	Untreated vines	65.3	1,043	91.8	7.7
	Difference	1.6	37	85.2	2.6
2. Cabernet-Sauvignon	Treated vines	71.3	1,075	178.6	4.6
	Untreated vines	70.2	1,053	116.2	6.3
	Difference	1.1	22	62.4	1.7
3. Cabernet-Franc	Treated vines	71.8	1,084	188.6	5.6
	Untreated vines	70.5	1,050	103.0	7.2
	Difference	1.3	34	85.6	1.6
4. Petit-Verdot	Treated vines	70.8	1,080	175.0	7.9
	Untreated vines	68.4	1,037	39.4	9.3
	Difference	2.4	43	135.6	1.4

It will, moreover, be well to mention the considerable difference between the color of the grapes and must of the treated and untreated vines. While the color is normal in the first, in the second it is much below the usual lower limit.

In conclusion, we will remark, how great the difference is in the alcoholic richness of wines from vines treated and untreated. In fact, from the quantities of sugar recorded in the preceding table, we may infer that, according to the varieties, wines of the first class will contain from 8 to 10 per cent. of alcohol, while the alcoholic content of wines of the second class will vary between 2 and 6 per cent. only.

This last observation comes to the support of a remark already made by one of us, to wit, that since the appearance of the mildew the alco-

holic richness of the wine has decreased throughout the Southwest, one year with another, 3°, or one-third of its absolute value. Since this period, numbers of proprietors have made wines of 2° to 3° which it has been necessary to re-enforce by foreign wines of high alcoholic standard in order to give color and preserve them. This year the effects of the scourge are so formidable that a large number of proprietors will not harvest anything. Especially in Gers the vine has been stripped of its leaves since the end of July, the grapes are still sour, and the wood not ripe. If these vines do not die in the course of a year, which is possible, we can at least assert that they will not be able to produce a crop under two years.

OCTOBER 10 1885.

XI.—ACTION OF SULPHATE OF COPPER ON THE MILDEW.

By M. Prosper de Lafitte.

[*Journal d'Agriculture Pratique*, October 1, 1885.]

September 29, 1884, M. Ad. Perrey pointed out to the Academy of Sciences the property which poplar-wood stakes, soaked for some days in a solution of sulphate of copper, possess of preserving the vine from mildew. The preservation is only relative; the stakes thus prepared only diminish the action of the fungus, their virtue being exerted to a distance not exceeding .25 meter [about 10 inches.]*

In September, 1884, the *Journal de Beaune* printed several communications on this subject:

On the 20th, notes by MM. Ricaud and Paulin; M. Ricaud cites the fact as "recently pointed out";

* In M. Perrey's note to the Academy the following are the most important statements:

In a vineyard in the department of Saône-et-Loire a plot containing 2,000 vines of Gamai, 4 to 5 years old, was restaked in the spring of 1884. Four hundred vines received old stakes which for several years had not been dipped; all the others received new poplar-wood stakes which for their preservation had been soaked in a saturated solution of sulphate of copper for four days. The old stakes were irregularly scattered over the plot. On September 15, not a single vine of the 410 which were tied to the old stakes retained more than two or three leaves, and these were more or less affected by the mildew. The 1,600 vines tied to the new stakes, on the contrary, retained all their leaves even in the midst of defoliated vines. These 1,600 vines were not absolutely free from mildew, but its effect on them was insignificant and confined to the branches farthest away from the stakes—*i. e.*, more than 10 inches away. The author says that upon these stakes he looked in vain for a vine that was badly injured.

On another plot of vines four to five years old, a part of the stakes were dipped in 1883 and the rest in 1884, but in a somewhat dilute solution. When these vines were compared with those on the old stakes, the preservative influence of the sulphate of copper was plainly visible, but they were not so well preserved as those tied up to the stakes which had been recently dipped into the saturated solution.

In no case did the beneficial influence of the copper reach outward from the stakes more than 8 or 10 inches. Vines closely tied up are said to have escaped entirely.—Tr.

On the 23d, a note by M. Montoy;

On a date unknown to me, a note by M. Bidaud.

M. Magnien, departmental professor of agriculture of the Côte d'Or, pointed out the same fact on the 25th of September; M. Jules Réginer, president of the *Comité central d'études et de vigilance*, of the same department, has himself made and controlled a number of similar observations on the estates of others.

Who first noticing an oasis of verdure in a vineyard stripped of leaves, had the sagacity to ascribe the phenomenon to the action of sulphated stakes? I do not know, and probably we shall never know. It may have been some worthy peasant who, unknown to himself, possessed the qualities of an observer.

Struck by the number and authority of the testimonies, and tempted by the boldness of a provisional explanation of the facts, I addressed a note to the Academy of Sciences, and resolved to submit to experiment the observations made in Burgundy; and in order that its control might be easier, I chose the nursery of the *Comité central d'études et de vigilance* of Lot-et-Garonne for the theater of this experiment.

Arrangement of the experiment.—I had at my disposal only a square of *Jacquez* planted from cuttings in April, 1885. This square measured 14 meters [46 ft.] on a side, and was divided into ten beds extending east and west, about 1 meter wide, and separated by narrow passages .45 meter wide. I employed the pine-wood stakes in use in the country.

On each bed were five rows of cuttings, including between them four spaces of .25 meter [about 10 inches]; the cuttings were in rows .1 meter apart. The stakes were uniformly distributed on the surface of each bed without reference to the place occupied by the cuttings, and in the following manner: There were four rows of them; two upon the edges of the bed, and two intermediate ones, the four forming three interspaces of .33 meter. The stakes were .50 meter apart in the rows; moreover, the stakes of rows Nos. 2 and 4 were planted midway between the consecutive stakes of rows Nos. 1 and 3. It can be readily computed that, according to this arrangement, no part of the surface of a leaf of *Jacquez* could be more than .25 to .26 meter [about 10 inches] distant from the nearest stake.

Of the ten beds, which we will suppose numbered from South to North, five received stakes which had been soaked in a *cold saturated* solution of sulphate of copper *for four days;* five received stakes not prepared in any way. The first were numbered 3, 4; 6, 7; and 10. The second were numbered 1, 2; 5; 8, 9. By design, in order that visitors might not be influenced by any consideration of symmetry, I made them follow each other irregularly.

The sulphated and unsulphated stakes were all of the same size; total length, 1.1 meter; length in ground, 0.4 m.; in air, 0.7 m.; length of part rising above foliage in September, 0.3 m. The diameter was about .025 m. [one inch]. The data given are sufficient so that, if any

one desires, the experiment can be repeated under the same conditions.

I wished to prevent the leaves of adjacent beds from intermingling. For this purpose I surrounded each bed with two horizontal rows of bands one above the other, and wound around each one of the stakes at the margin of the bed. For the beds with sulphated stakes, I used osier bark steeped, like the stakes, in the sulphate of copper solution. For the beds not treated, I made use of ordinary twine. In the applications, as will be noted later on, I attach a very great importance to the final action of these sulphated osier barks.

Facts established.—I noticed the first appearance of the mildew upon my *Jacquez* June 30, and, beginning with this date, I visited my experimental square every five or six days. Up to August 5 the progress of the disease was very slight. I thought I noticed a palliation on the treated beds, but it was so feeble that I always prudently wrote in my note book, "*Conditions not decisive.*" On the 16th of August I was no longer in doubt. That day I had the honor to receive a visit from MM. Jules Clavé, director of domains and forests, M. the duke of Aumale, and H. Bucan, steward of the domain of Zucco, in Sicily (I am authorized to use all the names mentioned in this note). Having conducted my guests to the square of *Jacquez*, without telling them what I had done, I asked them if they observed any differences in the health of the various beds. Without hesitation and without consultation, MM. Clavé and Bucan pointed out five beds as noticeably less diseased than the other five; these were the five beds with sulphated stakes. Then only was I certain of not being misled by a preconceived notion.

From this time the differences were distinctly emphasized. On the 25th, under the pretext of a walk, I requested M. Magen, general secretary of the central *Comité*, to accompany me to the nursery. When in sight of the *Jacquez* I asked the same question. My colleague, who is near-sighted, was obliged to follow all the narrow paths between the beds and take a close view of each bed. The abstract of notes made by him specifies without ambiguity the five beds with sulphated stakes as the finer. In fact, the differences appeared to me more distinct than on the 16th.

On August 28 I received a visit from M. Merle de Massonneau, one of the vice-presidents of the agricultural association of Nérac. M. de Massonneau immediately designated the five treated beds as strikingly finer and greener. The difference was obvious.

M. de Massonneau was so impressed with what he had seen that he took the trouble to return from Nérac on the 31st, to accompany MM. Klein, acting professor in the Faculty of Sciences of Marseilles, and Alb. Laporte, his colleague in the vice-presidency of the association of Nérac. I resorted to an artifice. I handed each one of these gentlemen a sheet of paper bearing the figures 1 to 10 written in a column. Each one of these figures represented a corresponding bed, and I requested them to write opposite, without previous consultation, the words *good* or

bad, according to the conditions of the bed. When filled there was complete agreement between the two sheets. M. Laporte, in returning his paper said: "My mind was absolutely made up at the first glance." The five treated beds were noted as "*good*," the other five as "*bad*." And yet, abundant rains having come on between the 28th and 31st, the vine reacted against the fungus. Like myself, M. Massonneau found the disease everywhere diminished, and the differences less marked than on the 28th.

The rains continued, and in my visit September 7 I noted a new attenuation, both of the mildew and of the differences between the treated vines and the others. On the 11th, I received a visit from M. E. Gassou, a large proprietor of the department, who, at the expense of his own vines, knew the mildew only too well. The situation had become very nearly what it was on the 31st; M. Gassou immediately pointed out five beds as finer, and, as usual, these were the five treated beds.

On September 18 the differences were again very marked. The date was approaching when I ought to make to the minister of agriculture the annual report of the *Comité central d'études et de vigilance*. I asked M. L. Boudet, general secretary of Lot et Garonne, to have the kindness to visit our nursery. MM. Bitaubé, counsellor of prefecture, and Debuc, chief of division in the prefecture, both my colleagues on the central committee, desired to accompany us. To each of these three gentlemen I gave a sheet of paper bearing in column the figures 1 to 10, as I had done to MM. Klein and Laporte. The sheets were filled out with entire unanimity, and specified the five treated beds as notably better than the other five. The latter show yellowish leaves, a yellow of the upper surface which is peculiar to mildewed leaves, and bear less developed branches. The others, although attacked, have a fine growth and color. The ripening of the grapes on the untreated beds would have been doubtful had there been any, but it would have taken place on the others as though the fungus were not there. Such was the common impression of our visitors.

Up to this time we had only estimates to go by; but on this visit I discovered a material fact, and was able to point it out to these gentlemen: On the beds not treated the leaves had begun to fall, while on the beds with the sulphated stakes not a leaf was wanting.

When we observe the surface of the square, the differences between the beds seem very well marked; but they appear much more so when we examine the borders of the beds, along which the branches stand upright supported by the double row of bands surrounding each plot. The action of the girdles of sulphated osier bark, appears even more efficacious than that of the stakes; but probably because the leaves situated on the borders are less remote from the bands than those in the center are from the stakes, and because they are less sheltered by each other.

Another experiment.—The nursery of the central committee is planted

in the garden of the normal school for governesses. A portion in the extreme north of the garden was granted me for experiments, and I separated it from the rest of the property by a ditch running east and west. Along this ditch, at intervals of one meter, I planted a row of California vines, raised from seed. M. Tisserand sent the seeds, asking me to try this variety. In 1885, these vines were three years old. In 1884, I mentioned them in my report as subject to mildew, and to such an extent that, whatever might be their qualities, they could not, from this fact, be of any importance in our region. These invited a second experiment.

Uniting these vines in groups of threes, I placed the sulphated stakes in the groups of the even rows, starting from the west, and the unprepared stakes in the groups of the odd rows. The branches of the even groups were tied up around the supports by sulphated osier bark, and the odd groups by ordinary twine. The branches grew beyond the tops of the stakes quite early, and according to the groups I then united the ends of these stakes by strands of sulphated osier bark or by twine. A second row of strings was placed .4 meter below the first. For a long time each of these two strands has been surrounded by a wreath of foliage .10 to .15 meter in diameter.*

On these groups of vines the mildew passed through the same respective phases as on the beds of *Jacquez*, and the same visitors at the same dates verified the same differences between the groups as between the beds. September 18, the groups treated could be recognized from the end of the garden by their vigor and fine verdure.† Upon the wreaths the differences are still more marked than upon the masses of the vines; probably because of the small size of these festoons, the leaves remaining very close to the bands around which the branches twine.

All the vines which figure in this second experiment are, without exception, considerably worse attacked on their east side than on the other three sides. We can there recognize the combined action of the sun and of the dew not yet evaporated in the morning.

DISCUSSION.

I. We have observed that the action of sulphate of copper becomes obvious only when the disease has acquired a considerable intensity. There is, consequently, no reason for astonishment that in 1885 no new information was received from Burgundy, since chance decreed that this year Burgundy should be one of the few districts spared by the fungus.

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* The stakes used were 1.9 meters long; 0.4 meter in ground, and about .045 meter in diameter.

† On September 16, in my absence, M. Lasserre, vice-president of the agricultural association of Agen, and my colleague on the central committee, visited the nursery. M. Lasserre, who was more than skeptical before this visit, wrote me that he observed a superior growth in the treated plantation of *Jacquez*, and was "dumbfounded" when he saw the results of the second experiment.

II. One circumstance is to be noted with regard to our *Jacquez* in the nursery; the square is near the north fence-wall, and consequently faces the side of the wall with a south exposure, being separated from it by an alley 3 meters wide. Against the wall, facing the square are planted 6 five-year old *Jacquez*, which entirely cover the face of the wall with their branches and foliage. On the south side, by an alley 1 meter wide, the square of *Jacquez* is separated from a square of the same size, planted to *York Madeira.* The west fence-wall is 15 meters from these two plots, and the east wall is about 35 meters from them.

Every year, in whatever part of the garden it might be placed, the nursery of *Jacquez* has been much injured by the mildew; that of *York* has never shown more than a few traces of it on a very small number of leaves. Contrary to expectation, the five-year-old *Jacquez* had always been spared up to this time. Last year, during infrequent visits which I made to the nursery (I had nothing in particular to observe there), each time I removed by hand the few leaves which were affected—perhaps sixty during the whole season—and that sufficed to give these *Jacquez* the appearance of an immunity comparable to that of the *York.* This year the five-year old *Jacquez* have already suffered considerably, and the *Yorks* have lost half their leaves, which are dead, while those that remain are little better. This is because the disease developed in our region in 1885 with an intensity never known before. Upon our hills, at a distance of 500 meters, a superficial view does not distinguish the vines from the fields, the colors so much resemble each other.

This being so, it is my conviction that the five non treated beds of my experimental square owed a relative immunity to the sulphated stakes of the neighboring beds, and I easily inferred that the action of the sulphate of copper showed itself at a distance of more than 1 meter; but that only at a very short distance is it energetic enough to give really practical results. I could not otherwise explain how these five beds, neighboring on the north and south to two such intense centers of the disease, should themselves be relatively so little injured. Bed No. 5 not treated, and the only one between two treated groups, is sensibly less diseased than the beds of the two other untreated groups.

III. In my note to the Academy, previously cited, I thought I ought to caution viticulturists against too great haste in extending to stakes of all sorts of wood the properties recognized in aspen and poplar stakes in general, the only ones which had given rise to the published observations. Pine can now be included in the list of substances that may be used for this purpose; but I still believe an experiment is necessary for hard-wood species, oak and acacia especially, although I am convinced that the experiment would succeed if tried.

IV. Nothing proves positively that sulphate of copper is the only body which can exercise a prophylactic or curative influence on the mildew; and nothing proves that we cannot employ it in different

physical conditions. Here is a large field for researches, but they are not within the reach of an ordinary viticulturist.

V. In spite of the number and authority of the witnesses, the discovery made in Burgundy in 1884 has encountered little but incredulity; while some observations entirely opposed have sprung up in other regions. My experiment proves, I believe, that there is nothing contradictory in these. I used eight stakes per square meter—that is to say, 80,000 to the hectare [2.47 acres]. In Burgundy the number of vines per hectare—that is, the number of stakes—varies from 20,000 to 24,000, which is only about one-fourth as many. In regions where the number of vines per hectare is only from 3,000 to 5,000 the conditions are entirely different, for the portions protected by the sulphated stakes are insignificant in comparison with the total area, the luxuriant vegetation of these vines sometimes covering the whole surface of the earth. It is not surprising, therefore, that under these conditions the phenomenon may have escaped the notice of even attentive viticulturists.

VI. Any explanation of the facts observed can be yet only purely hypothetical, and it is best to wait. Still, I ought to say a word upon a question which has been raised, and which concerns the manner of application: Which acts, the buried portion of the stake, or that part in the air? The subterranean action of the stake driven near the vine would extend in a circular manner and uniformly over all the root-system to a certain distance from the trunk, not acting upon one group of roots more than on another; and then the action on the foliage ought also to extend over all the aerial system of the plant. Now, this is not what was observed in Burgundy. Without exception, all observers are agreed in limiting the action of the stakes to the interior of a cylinder having for its axis the stake and a radius of .25 m. It is, therefore, certainly the portion in the air which acts, or at least the action of that part is much the greater. Next year I will submit these views to a direct and simple experiment. It was from fear of confusing all by undertaking too much in so small a compass that I did not do so this year.

VII. Next year the sulphated stakes which have served this year will show whether preventive or curative virtue remains from one year to another.

Application in vineyards.—Are we, therefore, obliged to use 80,000 sulphated stakes per hectare? Fortunately not.

Let us first consider vines trained upon iron wire. From the above facts I consider it very likely that simple sulphated osier bark wound along the iron wires will suffice, and we might, if necessary, add one or two supplementary strings fixed simply to the stakes. Elsewhere we can replace the osier bark by large ropes or by those of very small diameter as 2 to 3^{mm}.

Another method: Strips of poplar of small cross-section, say 1 centi-

meter, or 1½, on a side, can be produced very cheaply by a sawing machine, and when they have been sulphated it will be enough to tie these little strips to the iron wires, another row of the latter being put on when necessary. In many places in this way the railroad fences are made. These strips should be placed .4 to .5 meter [16 to 20 inches] apart, and might besides be combined with osier bark and ropes.

Let us now consider vines which are pruned in goblet-form: Here the sulphated stake will be the pivot of defense; bands of any sort will complete it. Some tiers of osier bark or ropes placed circularly at distances of .4 to .5 meter from each other, winding around the branches successively, and supported by them, beginning with the stake and returning to it at last to be tied there, will serve, it seems to me, to solve the problem *provisionally*. As happens in all treatments, the beginnings of which were most unpretending, time ought finally to bring its quota of new ideas.

But what will be the expense? The manual labor will be the principal one. It is no small expense, and I ought to once more state the radical difference between vines which yield bountifully and those which yield scantily. For the first, the expense is scarcely to be considered, in any case it is not an insurmountable obstacle, and at present it appears to me that we can protect them with success; as to the others, there is, and always will be a balance to make up between the receipts and the expenditures.

Other fungus diseases.—At least is it not very probable that any treatment which will be successful against this terrible mildew, which conceals itself in the parenchyma of the leaves, will, *a fortiori*, succeed against all other fungus diseases? However, I affirm nothing, because it is wiser to await experiment; but what progress and what economy do we not owe to Burgundy, if this treatment can replace all others, especially sulphuring, which must be renewed so often!

The *black-rot*, a new scourge which we owe to the American vine, deserves special mention, while waiting for those the vine may yet have in store for us.

The chosen place of this new parasite is the grape berry. Now, the fruit is only a short distance from the base of the fruit-bearing branches on vines in rows, on palings, or on trellises, or even from the vine when pruned in goblet-form; some meters of osier bark or of any sort of rope will suitably protect all the wood in the vicinity of the bunches.

All these and other considerations suggest themselves, but in this new treatment, as in that for the *winter spores*, I have nothing to claim for myself, unless it be good will.

XII.—TREATMENT OF MILDEW BY A MIXTURE OF SULPHATE OF COPPER AND LIME.

By Messrs. MILLARDET and GAYON.

[*Journal d'Agriculture Pratique*, November 12, 1885.]

The good effects of the treatment of mildew by sulphate of copper and lime are to day beyond all dispute. It remains to explain the mode of action of this treatment, why it has been chosen in preference to others, and for what reasons it appears improbable that it will undergo important modifications, although probably susceptible of some improvement.

The observation which led me to apprehend the principle underlying the treatment dates back several years. I was studying the development of the conidia, or summer spores, of the *Peronospora*, when I found that these reproductive bodies would not develop in the water of my well, but when sown in the city water, in dew, rain-water, or distilled water, they continued their evolution uninterruptedly to the formation of zoöspores.*

The explanation of this strange fact eluded me for a long time. It occurred to me only at the last moment as we shall see farther on. As the water of this well is heavily charged with calcareous salts, and cooks vegetables badly, at first I thought its deleterious action on the conidia might be due to this peculiarity. But whatever might be the cause of this action, I inferred therefrom that in all cases its extremely feeble and not easily appreciable influences were capable of preventing the development of the reproductive bodies of the parasite.

On the other hand, as I had taken into account the impossibility of destroying the *Peronospora*, without at the same time destroying the leaves which are attacked by it, since the parasite grows exclusively in the interior of these organs up to the moment of its fructification, I had reached this conclusion: that the treatment of the mildew could only be preventive. It ought to answer, as I have said, "to cover preventively the surfaces of the leaves with various substances capable of destroying the vitality of the summer spores, or, at least, of hindering their germination."†

* This fact was recorded in the *Annales de la Société d'Agriculture de la Gironde*, 1885, p. 79.

† *Annales de la Société d' Agriculture de la Gironde, loc. cit.*

I had, therefore, reached this point when, in 1882, I was a witness for the first time of the fungicide action of a mixture of sulphate of copper and lime, employed from time immemorial in Médoc to prevent marauding.

In spite of the fact that this metal was present in an almost insoluble state, it seemed to me that the agent really active in this mixture must be copper.

Accordingly, during the following year (1883), I devoted myself to continuous researches upon the efficacy of various salts of copper (the sulphate, carbonate, phosphate, and sulphuret), and the corresponding salts of iron,* as well as upon the value of lime in powder or mixed with water. These experiments were repeated by Mr. David, in Dauzac, at Mr. Johnston's, who, with a generosity I cannot thank too heartily, had placed his estate at my disposal for these experiments. At the same time mixtures were tried with varying proportions of the sulphate of copper and lime.†

In 1884 the same experiments were continued, but without absolutely certain results, because there was only very little mildew at the place where they were made, and it was impossible to judge exactly and comparatively of the effect produced by the various methods of treatment. Nevertheless, the researches of these two years enabled me and Mr. David as well to ascertain that of all the substances employed the mixture of sulphate of copper and of lime was the one which produced the best results.

I had been led to give up treatment by the sulphate of iron and even by the sulphate of copper, which, however, appears since to have given quite good results,‡ because the spraying of these solutions is difficult and is harmful to the vine. With doses exceeding in strength ½ per cent. of sulphate of copper and 1 per cent. of sulphate of iron in distilled water, I invariably burned the young shoots and often the leaves, especially if the spray was not very fine, and if the liquid gathered itself together in drops. Moreover, for the end in view the small quantity of the salts deposited on the leaves by this process appeared to me insignificant. In powder, lime alone appeared to be almost inert and milk of lime (only one application) scarcely more active.

For these reasons, in 1885 Mr. David and I turned our attention to the mixture of sulphate of copper and lime, employing the two substances in the proportions which, from the experiments of the two preceding years, appeared to be the best. This is one of the reasons why

* I was aware from my experiments upon the "*fungivore*" that the salts of iron have a favorable action on the mildew.

† All these experiments performed at Dauzac are, with their respective dates, recorded in the Farm Journal of the Château Dauzac. This important document has been transmitted to the commission named by the Agricultural Society of Gironde for a study of the results of this treatment.

‡ Particularly in the hands of Messrs. Ad. Perrey, P. de Lafitte, and Magnien.

the result of the treatment has not been as satisfactory anywhere else in Médoc as at Dauzac.

Besides, as to the effects of various treatments with the above-mentioned substances, another method gave results which confirmed those obtained by direct observation in the vineyard.

When we place the conidia of *Peronospora* in contact with pure water, at a temperature above 9°C. [48 Fah.], after an hour or an hour and a half, they emit zoöspores. At first, during 3 to 5 hours,* the latter swim about rapidly in the water, then come to rest, settle down, and emit a germ-tube,† which pierces the epidermis of the leaf, and penetrates into its tissues; so that in pure water, in from six to eight hours after the beginning of the experiment, the infection of the leaf by the parasite is accomplished.

But, if we employ dilute solutions of lime, sulphate of copper, or sulphate of iron, we find that the conidia and the zoöspores which they produce are remarkably sensitive to their influence. If the solution is a little too concentrated the development of the conidia, the latter do not emit zoöspores, but die without undergoing noteworthy change. If the liquid is a little less concentrated, some zoöspores are formed; but instead of moving rapidly in the liquid, they drag about slowly, soon come to a standstill without germinating, and quickly perish. If, proceeding in another way, we sow the conidia in a quantity of distilled water to which we add, as soon as the zoöspores are in motion, increasing doses of a solution of sulphate of iron or copper, or of lime of given strength, there comes a moment when the zoöspores stop and are killed.

Experience has taught me that the limit of concentration incompatible with the complete development of the reproductive germs is—

For lime, a solution of 1 to 10,000.

For sulphate of iron, a solution of 1 to 100,000.

For sulphate of copper, a solution of 2 or 3 to 10,000,000.

That is to say, the salts of iron, although very active, are about one hundred times less so than those of copper, and the lime is ten times less active than the iron.

From this it will be understood why the brothers Bellussi, in their experiments with the milk of lime, found it necessary to make five or six successive applications in order to obtain a satisfactory result.

We also see that it will be difficult to find substitutes for the salts of copper on account of the wonderful energy of their action upon the reproductive germs of the *Peronospora*.

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*My own observations and the statements made by Dr. Farlow and others lead me to think this is an error. The zoöspores usually come to rest and emit a germ-tube, or perish, inside of one-half hour. Conidia, however, keep germinating for some time, and the author may have had this in mind.—Tr.

†See my memoir, Mildew and Rot, in *Zeitschrift fur Wein-Obst-und Gartenbau für Elsasz-Lothringen*, March 1 and 15, 1883.

The rôle of lime in the mixture, as we shall see further on, appears to be less important.

Only after having obtained these results has it been possible for me, thanks to the co-operation of Mr. Gayon, to account for the above-mentioned fact, which in reality was the point of departure of all my investigations; I mean the absence of development in the conidia when I sowed them in the water of my well.

This well is 11 meters deep, and the water is raised by means of an old copper pump. An analysis of the water showed 5 milligrams of copper per liter, or more than ten times as much as is necessary to kill the reproductive germs of the *Peronospora*. I ought to add that I have occupied the house six years, and that, up to this time, all the family have drunk this water without the least inconvenience. This fact is interesting, for Mr. Gayon will soon tell you that, as a rule, the wines from the vineyards which have undergone the treatment here discussed, contain but little more than one-sixth as much copper as was found in the water of the well.

There remains for me to mention another obscure fact, but one of prime interest, which only a chemist could make clear. The explanation of this is due also to the co-operation of my learned colleague.

The copper in the mixture and upon the leaves is in the condition of a hydrated oxide, which is generally regarded as insoluble. It is in the form of amorphous granulations that can be seen with the microscope. At first these are inclosed by lime and sulphate of lime, and later are protected by a solid crust of slightly soluble carbonate of lime. Now, it is shown by the researches of Mr. Gayon that this oxide is slowly but completely dissolved in water, holding carbonate of ammonia in solution, at the temperature of 15° C.; that water charged with carbonic acid can, at the same temperature, dissolve 40 milligrams of it per liter; and, finally, that at the temperature of 15° C., pure water itself dissolves traces of this same oxide.

The tiny drops of the cupro-calcic mixture, disseminated upon the leaves, act, therefore, like true reservoirs of oxide of copper, preserving the latter for weeks and months under their calcareous crust, and yielding to the dew and rain, which is more or less charged with carbonate of ammonia and carbonic acid, the minute quantity of copper necessary to stop the development of the conidia, which the wind deposits on the surface of the leaves. Therefore, the lime seems to me to play a triple rôle in the mixture. At the moment of spraying, it behaves like an active mordant, which fixes the preservative drop upon the leaf and causes its close adherence. For some days it is capable of killing the conidia and the zoöspores by its caustic properties. Finally, when it is transformed into carbonate, it serves for the preservation of the stock of oxide of copper.

If the theory which I have just set forth needs proof, we shall find it in the following experimental fact, which several persons have this year

verified in Médoc. The treatment has produced its maximum effect only where it has been applied in a preventive way. From the 1st of April last I have strongly insisted on this important point.

In this journal, October 8, 1885, as well as in my communication to the Academy of Sciences on the 5th of the same month, I presented the sulphate of copper and lime treatment as a remedy for both mildew and rot. I may be permitted to give a brief explanation of this subject.

As already stated, it was in 1883 that first of any one in Europe, I described and figured the rot in the Alsatian journal mentioned above. As I have clearly proved, the rot is produced by the development of the mildew upon the branches of the bunch, and in the interior of the berries. This is, I think, the variety of rot most common in America [?] and probably the most important for us. Since this work, of which I have just spoken, I have learned to know another variety of rot, which is a result of the development of *Anthracnose* upon the branches of the bunch. Finally, according to some recent statements which need confirmation, there exists yet a third variety of rot, caused by a fungus of the genus *Phoma* [See Appendix A].

When I stated in one of my former articles that the treatment for mildew was of equal service against the rot, I had in view only the first-mentioned variety of rot, that which is connected with the mildew. This rot is only an effect, and in preventing the mildew upon the leaves we prevent, at the same time, the invasion of the bunch by the same parasite.

XIII.—PRACTICAL TREATMENTS FOR THE PREVENTION OF MILDEW.*

By G. Foëx.

[*Le Vigne Américaine at la Viticulture en Europe*, June, 1886.]

REMEDIES TO EMPLOY.

2.—Podechard Powder.

Good results have likewise been obtained in the Côte-d'Or by the use of a powder made in the following manner: A lime milk is prepared out of, lime, 5 kilograms; water, 10 kilograms; and a solution of sulphate of copper out of, sulphate of copper, 10 kilograms; boiling water, 20 kilograms.

The two liquids are allowed to cool to 25°C. [77°F.], mixed, and then poured upon 100 kilograms of quicklime, which is allowed to slake. This powder probably acts like the copper mixture of Gironde.

This remedy which has given positive proofs of its efficacy in Burgundy, has not been tried in the South, and it is consequently impossible to know yet whether it will prove effective in the climate of that region. Nevertheless, on account of the ease of application, which is greater than in case of the copper mixture of Gironde, it deserves to be tried with care.

3.—Sulphated Stakes.

Stakes sulphated with a view to their preservation, have served to completely protect certain vineyards in the Côte-d'Or. The small number of branches of each vine tied in a bundle of three or four upon the support, and the frequent rains which wash the latter and carry the dissolved sulphate of copper to the leaves which are very near, explain this phenomenon. In order to increase the efficacy of this arrangement, it has been proposed to bind the branches with straw bands dipped in the sulphate of copper. The employment of this means, besides, being quite expensive, has given no result in the vineyards of the Mediterranean region, probably because of the lack of moisture during the summer.

* The author's preliminary description of the *Peronospora* is omitted, and the description of the "copper mixture of Gironde" will be found on page 15 in the body of this Report.—Tr.

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4.—The Audoynaud Process.

Mr. Audoynaud has proposed to apply the copper to the leaves in the form of "blue water" or ammoniacal sulphate of copper, which enables us to get the substance in a very finely divided state, and consequently to greatly reduce the amount required per hectare.* The liquor is prepared in the following manner:

In a stoneware or glass jar place 2 kilograms of sulphate of copper upon which pour two or three liters of warm water, and stir with a stick or glass rod to hasten the solution. When the liquid is cold add about one liter of commercial ammonia (22° Beaumé), then, in a suitable cask, mix enough water with this liquid to make from 100 to 150 liters, which is the amount that should be put on one hectare. The Riley spraying machine, with a receiver like that constructed by Mr. Vermorel, of Villefranche (Rhône), appears to be the most convenient instrument for distributing this liquid. Although this process has not yet been carried out practically, it is probable that it will give satisfactory results if, like the copper mixture of Gironde, it is applied as a preventive.

CHOICE OF MATERIAL.

Sulphate of copper is a salt found in commerce in the form of large translucent crystals of an azure blue. When pure it contains:

Oxide of copper	31.84
Sulphuric acid	32.06
Water of crystallization	36.10
	100.00

The copper being the agent acting upon *Peronospora*, it is important to ascertain the purity of the sulphate purchased. Now, we frequently find in commerce double sulphates of copper and iron, or of copper and zinc, which are sold as sulphate of copper. Mr. Millardet gives the following methods of determining the purity of this salt:

By pouring some drops of lime water or milk of lime into a solution of sulphate of copper (1 to 10) we obtain a sky-blue precipitate from pure sulphate of copper; a rusty blue from the double sulphate of copper and iron; and a dirty white from the double sulphate of copper and zinc.

The lime which has given the best results so far is quicklime.

APPARATUS AND RECEPTACLES FOR HOLDING THE COPPER COMPOUNDS.

The sulphate of copper attacks iron and zinc, and ought, therefore, to be kept in vessels of copper, lead, wood, or earthenware.

* 1 hectare = 2.47 acres.

SUMMARY.

Although the processes which have just been described deserve to be tried in the South (except the sulphated stakes), the "copper mixture of Gironde" is the only one that can be employed immediately on a large scale with certainty of success. Probably its action will not be limited to the destruction of *Peronospora*, but will tend to the destruction of several other fungus diseases of the vine.

XIV.—SEARCH FOR COPPER ON THE VINES TREATED WITH THE LIME AND SULPHATE OF COPPER MIXTURE AND IN THE HARVEST.

By Messrs. MILLARDET and GAYON.

[*Journal d'Agriculture Pratique*, November 19, 1885.]

After having disclosed the treatment of mildew by the mixture of lime and sulphate of copper, described its effects, and explained its action, as regards the treatment itself; it was important to give an account of the distribution and persistence of the copper on the plant, and of the duration of its action. From a hygienic point of view it was not less important to determine exactly the proportions of a substance as poisonous as copper which might exist on the grapes, in the must, and in the wine. It is to be hoped that, from this double point of view, these new inquiries will not be devoid of interest. The quantities of copper to be determined were so minute that only the most delicate analytical processes were capable of showing them. All the organs of the plant (leaves, etc.) and all its products (must, wine) were first incinerated with care. The ashes were then submitted to electrolysis, with the precautions indicated by Mr. Riche, and the amounts of copper precipitated from their solutions were finally estimated by the calorimetric method. The sensitiveness and accuracy of the method, especially as regards the wine, were established by several contrôl experiments, in which a tenth of a milligram of copper, in the form of the sulphate, added to a liter of pure wine, was always recovered in its entirety.

The following table will give a general idea of the amount of copper found on the various parts of the vine and in its products. The samples of leaves, branches, and stocks were gathered during the first half of October.

The grape-stalks were not fermented.

The musts were obtained from the 8th to the 12th of October by direct expression from the grapes. The samples of grape-cake were procured during the tunning, at the same time as the wine; that is, after the end of the fermentation.

Tables of analyses.

LEAVES, BRANCHES, ETC.

Portions analyzed.	Variety.	Total weight in grams.	Weight of ash in grams.	Milligrams of copper contained in the ash.	Milligrams of copper per kilogram.
1. Leaves not dried	Cabernet-franc	640	17.02	12.3	19.1
	Carbernet-Sauvignon	290	13.96	20.2	69.6
	Malbec	680	20.82	65 0	95.5
	Petit-Verdot	630	18.20	45.7	24.9
2. Branches and stump	Cabernet-Sauvignon	1,677	35.52	9.8	5.8
3. Grape stems, *i. e.* clusters from which the grapes have been removed.	Cabernet-franc	1,835	35.52	27.6	15.0
	Cabernet Sauvignon	102	2.53	1.9	18 6
4. Grape-cakes (skins and seeds).	Cabernet-franc	1,500	16.66	16.7	11.1
	Various kinds mixed	1,365	26.25	29.9	21.9

MUSTS.

Variety.	Amount of must in centiliters.	Milligrams of copper per liter.
Cabernet-franc	723	1.4
Cabernet-Sauvignon	802	1 2
Malbec	777	1.0
Petit-Verdot	652	2.2

WINES.

Origin of the wine.	Milligrams of copper per liter.
Château Dauzac	Less than one-tenth milligram.*
Château Pez	Doubtful traces.
Château Poujeaux	Do.
Château Langoa	Less than one-tenth milligram.

* One-tenth milligram = 0.0015432 grains.—TR.

From these figures it is apparent that, at the time of the vintage, the leaves are the richest in copper, and next the stems of the cluster and the skins. It appears probable from facts upon which it is not possible to insist here, that almost all this copper is simply adherent to the surface of the organs. The musts contain extremely small quantities of this metal. As to the wines, they show only the minutest traces, if any—at most one decigram [1.54+ grains] per thousand liters [1,761 gallons].

But, as considerable quantities of copper are introduced into the vintage tubs with the stems of the clusters in certain countries where the grapes are not picked off, and everywhere with the grape skins, it was important to find the cause which determines the almost complete disappearance of this metal from the wine. Experiments which it is unnecessary to narrate here, made to throw light on this particular point, have shown that the more or less complete absence of copper from the wine must be attributed to the action of fermentation. This metal is precipitated and is found in the lees. Tannin and sulphur added to the musts before fermentation favor this purification of the wine. This last fact is in accord with the statement made some days since, by

Mr. Michel Perret, in reference to the action of sulphur on the soluble salts of copper during fermentation.*

The comparison of the total quantity of copper found on the whole vine more than two and one-half months after treatment, with the amount put upon it, gives occasion for remarks not less important than those just read. The following is the result of the analysis of an entire vine, taken at random, in a vineyard at Dauzac, which was treated about the 15th of July. This vine was pulled up the 8th of October. It is the same vine (Cabernet-Sauvignon) mentioned in my article of October 12, as typical.

Analysis.

Part of vine:		Milligrams of copper found.
Leaves		20.2
Branches and stumps		9.3
Roots		1.9
Grapes:		
Stems of clusters	1.9	
Grape-cake (skins and seeds)	1.8	4.6
Must	0.9	
Total		36.0

This 36 milligrams of copper corresponds to 143 milligrams of crystallized sulphate of copper.

We have previously stated that on an average, for the treatment of 3,000 vines 8 kilos of sulphate of copper were used, which gives 2,667 milligrams [41 grains troy] of the salt per vine. After two months and one-half, we found on the entire vine, only 36 milligrams of copper, that is to say, only about 5.5 per cent. of the quantity originally put on the leaves. The remainder, 94.5 per cent. was therefore washed off by the rains and carried into the soil.

It should be stated now that the summer was dry in Médoc from July 10 to September 1, there being only three or four days of rain or storm. During all this time the amount of copper placed upon the leaves ought not to have diminished much. There remained, therefore, a very considerable provision of copper when the rains of September came on, determining the formidable outburst of the mildew, following which the leaves fell in a few days. It was without doubt these rains which washed off the greater part of the copper put upon the plant in the treatment, so that on October 8 there remained on the entire foliage only 20 milligrams, that is, about 3 per cent. of the original quantity.

What would have occurred if the rains of September had fallen in the middle of August, or at the end of July? Would the 20 milligrams of copper which persisted on the leaves have been sufficient to protect them with certainty from the mildew until the ripening of the grape? It is questionable.

For this reason, if abundant and prolonged rains occur toward the beginning or the middle of August, after the treatment and at a period somewhat remote from the ripening of the grape, it would be prudent to make a second application of the preservative mixture.

**Journal d'Agriculture Pratique,* October 29, 1885.

Appendix D.

RESULTS OF THE CONGRESS ON PARASITIC DISEASES OF THE VINE, HELD AT FLORENCE, ITALY, OCTOBER, 1886.*

The interest and importance attached to mycological work in France and Italy is shown by the fact that there was recently held at Florence, Italy, an International Congress for the exhibition of machines and apparatus for the preparation, transportation, distribution, and application of remedies against fungi and insects. At the same time there were held several special meetings for the discussion of the fungus diseases of the vine and the remedies to be employed against them. An effort was made to have the Department represented at this Congress by a special agent, in order to receive an early and full report of the proceedings. This attempt was unsuccessful, but an official abstract has been received, and this is presented herewith, as containing the latest and most authoritative statements regarding remedies.

Conference I.

Members of the Commission: Cantoni, president; Cavazza, Cornu, Toscanelli, Lawley, Niccolini, Foëx, and Cuboni.

First subject: The *Peronospora*—its nature and its development in relation to external conditions, variable or permanent.

Second subject: The *Peronospora*—its development in relation to systems of vine cultivation, to varieties, and to the various organs of the vine itself.

CONCLUSIONS ON SECOND SUBJECT.

(1) The *Peronospora*—mostly attacks vines which are trained low or are unprotected, and not those which are trained up high and sheltered.

(2) Up to the present time no variety is known which is entirely free from attacks of the *Peronospora*. Nevertheless, the different varieties show different degrees of resistance, especially when the infection is not

*Comizio Agrario di Firenze: Conferenze sulle Malattie crittogamiche della Vite, Ottobre, 1886, Conclusioni e voti. Firenze, Tipografia della Pia Casa di Patronato 14 Via Oricellari, 1886.

very great. This diversity of resistance seems to depend either upon the internal organic structure of the variety, or upon the conditions of development.

(3) The *Peronospora* attacks especially the leaves, and sometimes also the other green parts. In the latter case, the form undoubtedly most grave is that which manifests itself upon the peduncles, upon the flowers, and in the grape-berries.

Conference II.

Members of the Commission: Caruel, president; Bellussi, Briosi, Cerletti, Comes, Comboni, Cuboni, Foëx, Mach, Sestini, and Cavazza.

Subject: The *Peronospora*—gaseous, powdery, and liquid remedies; results obtained.

conclusions.

(1) The gaseous remedies applied against *Peronospora* have not given any useful results.

(2) Among pulverulent remedies, tried thus far, the most efficacious are those into the composition of which sulphate of copper enters.

(3) The mixture of lime and ashes and of lime and sulphur have not yet given results sufficient to enable us to recommend their use. In some localities satisfactory results have been obtained from the use of sulphurous acid (*solfo acido*).

(4) Among liquid remedies, the milk of lime, suitably prepared and applied, has given good results. However, from a practical and economic standpoint, its use in many places encounters serious difficulties.

(5) Among truly efficient remedies, the mixed liquids or solutions containing sulphate of copper have, so far, given the best results.

Conference III.

Members of the Commission: Caruel, president; Bellussi, Briosi, Cerletti, Comes, Comboni, Cuboni, Foëx, Mach, Cavazza, and Sestini.

First subject: The *Peronospora*—action of the remedies; time and means of applying them.

conclusions.

(1) The action of the remedies is preventive; therefore only the preventive application can check the invasion of the *Peronospora;* and subsequent applications are useful only in so far as they prevent future invasions of the disease.

(2) In localities much subject to the *Peronospora* it is necessary to apply the remedies before the blossoming. In all places it is necessary to apply these in the most energetic way as soon as the *Peronospora* makes its appearance, and to repeat the applications according to necessity and the nature of the remedy.

(3) Aside from the choice of remedies, the manner of application depends upon the economic and culture conditions of each vine-growing region, and upon the earlier or later appearance of the disease.

Second subject: The *Peronospora*—influence of the remedies upon the composition of the musts and of the wines.

CONCLUSIONS.

(1) The action of sulphurous acid, save to produce hydrogen sulphide in the same way as ordinary sulphur, and perhaps to increase slightly the quantity of the sulphates, can produce no notable change in the chemical composition of the must and no injurious effect upon the hygienic properties of the wine.

(2) The acidity of the must and of the wine is diminished a little by the action of the lime in powder and the milk of lime, but such a reduction does not ordinarily prove hurtful to the vinification. In cases, not frequent, however, where the acidity of the must is very low, this may be increased by the addition of tartaric acid.

(3) In regard to the effect of the treatments with sulphate of copper in powder or in solution, rather encouraging results have been obtained from the analyses already made as to the amount of copper contained in the wine, especially when it is made from grapes which have been sulphured either on the vine or in the vat. Nevertheless, the Assembly recognizes that grave commercial and hygienic questions are involved, concerning which in the present state of our knowledge it is not able to render a definite conclusion.

Conference IV.

Members of the Commission: Arcangeli, president; Foëx, Viala, Trentin, Pirotta, von Thümen, Briosi, Ottavi, and Penzig.

Subject: Anthracnose and the Black-rot.

CONCLUSIONS.

(1) Anthracnose (*vaiolo*, *bolla*) is caused exclusively by a microscopic fungus named *Sphaceloma ampelinum*, De Bary. Atmospheric humidity favors the development of this disease, which attacks different kinds of vines with various degrees of severity (?) (*in modo variabile*).

(2) Of the remedies proposed thus far to prevent anthracnose the treatment of the shoots and stems with acid sulphate of iron has given the best results.

(3) The cases of disease of the grape-berries, found in Italy and believed to be the black-rot of America, cannot yet be identified with that disease.

[Conferences V. and VI. were taken up with the discussion of the black disease (*mal nero*) and the rotting of the roots of vines, diseases which have not attracted any attention in this country, and which do not appear to be due to parasitic fungi.]

EXPLANATION OF PLATES.

PLATE I.—*The Downy Mildew.*

The two leaves occupying the upper part of the plate illustrate the appearance of the mildew on the lower surface of the leaf and its action in discoloring the upper surface.

a. Diagram showing a section of a fragment of a leaf infested by the Downy Mildew. In the parts affected the tissues of the leaf have changed from green to dark brown. The external growth of the mildew from the lower surface is drawn on a somewhat larger scale in order to show it more clearly.

b. Five conidiophores issuing from one of the stomata of the leaf, and bearing conidia.

c. Two of the conidia highly magnified.

d. Section through an old and dead leaf showing the resting spores.

e. Three of the resting spores, highly magnified (after Cornu).

PLATE II.—*The Downy Mildew* (on the berries).

From an original photograph. To the left are shown three healthy berries gathered at the same time from the same vine.

PLATE III.—*The Black-rot.*

From an original photograph.

PLATE IV.—*Downy Mildew* (*Peronospora viticola*).

Fig. 1. A conidium of *Peronospora viticola.*

Fig. 2. A conidium in which the contents, the protoplasm, is differentiating into zoöspores, shown by the dark lines.

Fig. 3. A zoöspore with its two cilia.

Fig. 4. The same, having lost its cilia and assumed a definite outline.

Figs. 5 and 6. Germinating zoöspores.

Fig. 7. A conidium germinating by the emission of its entire undivided contents. This manner of germination was observed in conidia placed on water and kept at a temperature below 20° C.

Figs. 8 and 9, show the production of the germinal tubes in the protoplasmic mass from Fig. 7.

Fig. 10. A conidium germinating by the direct formation of a germinal thread.

Fig. 11. Fecundation of the oöspore from a sample found in the tissue of a mildewed leaf that had been kept under a moistened bell-glass for eight days; *a*, the antheridium when about to emit its protoplasm into the oögonium.

Fig. 12. An oöspore (after Cornu).

Fig. 13. An oöspore (after Prillieux).

Fig. 14. A fragment of mycelium showing the suckers or haustoria *a*, *a* (after Farlow).

Fig. 15. A fragment of mycelium separated from the tissues of the leaf (having been treated with acetic acid and potassa), *a a* haustoria. (Figures 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15 are redrawn from Viala in *Les Maladies des Vignes.*

PLATE IV.—*Powdery Mildew* (*Uncinula spiralis*).

Fig. 16. A fragment of the mycelium of the Powdery Mildew having two haustoria *b*, *b*, and three upright conidia-bearing filaments; *a*, *a*, conidia that have fallen from their supports.

Fig. 17. Epidermis from a grape-berry, the dark portion showing the discoloration caused by the action of the mildew.

Fig. 18. The mature form of the *Uncinula* found on the leaves of the Virginia creeper (*Ampelopsis*). Although believed by some botanists to be the same species as that found on the grape and figured in Plate V, the appendages are shorter and less numerous. The central dark body is called the perithecium while the radiating arms are termed appendages.

PLATE IV.—*Powdery Mildew* (*Uncinula spiralis*)—Continued.

Fig. 19. The asci from the perithecium of the *Uncinula* of the vine (after Farlow). Each ascus contains a number of spores called sporidia or ascospores.

PLATE IV.—*Black-rot* (*Physalospora Bidwellii*).

Fig. 20. A fragment of the epidermis of a grape diseased by black-rot, showing the pustules caused by the development of the perithecia of the Phoma, and the Phoma spores escaping in gelatinous, twisted, worm-like threads.

Fig. 21. A section through the fungus of the black-rot, showing in the same stroma two fruiting forms—the pycnidia and spermagonia, the latter being the smaller. The mycelium of the fungus is seen spreading through the tissues of the berry from the black, pseudo-parenchymatous tissue of the walls of the perithecia.

Fig. 22. A portion of a pycnidium more highly magnified, showing the short stalks or basidia, to which the Phoma spores are attached.

Fig. 23. Three Phoma spores germinating.

Fig. 24. A section through the mature fruiting form of the fungus, showing numerous asci contained within the dense-walled cavity of the perithecium.

Fig. 25. Two separate asci, more highly magnified, each containing 8 sporidia.

Fig. 26. A group of four sporidia still further enlarged.

PLATE V.—*Mature form of Uncinula spiralis.*

The perithecium with its hooked appendages. The perithecium has burst on one side and from the aperture two of the asci have escaped and one is just escaping. The ascospores are clearly visible within the asci.

PLATE VI.—*Anthracnose.*

a. A cluster of grapes diseased with anthracnose.

b. The appearance of the disease as it affects the young shoots and leaves.

c. A section of a portion of a diseased berry: to the right the fungus is shown developing just beneath the cuticle and to the left of the same figure the fungus is seen to have burst through the epidermis.

d. A section through an older diseased spot, the surface of which appears to be covered with a mass of spores.

e. Spores germinating.

PLATE VII.—*Diseases of the grape leaf.*

a. A leaf diseased by the grape-leaf blight, *Cercospora viticola*.

b. A group of hyphæ which bear the spores or conidia.

b^1, b^2. Conidia beginning to germinate.

c. A leaf attacked by the leaf-spot disease, *Phyllosticta Labruscæ*.

d. A magnified fragment of the same leaf, showing several of the perithecia seen from above.

e. Outline figures of the spores of *Phyllosticta Labruscæ*, highly magnified.

Between *b* and *d*, a minute fungus is shown which is sometimes found on dead spots upon grape leaves.

Geo. Marx. fecit.

A. Hoen & Co. Lithocaustic, Baltimore

DOWNY MILDEW,

Peronospora viticola.

A. Hoen & Co. Lithocaustic, Baltimore.

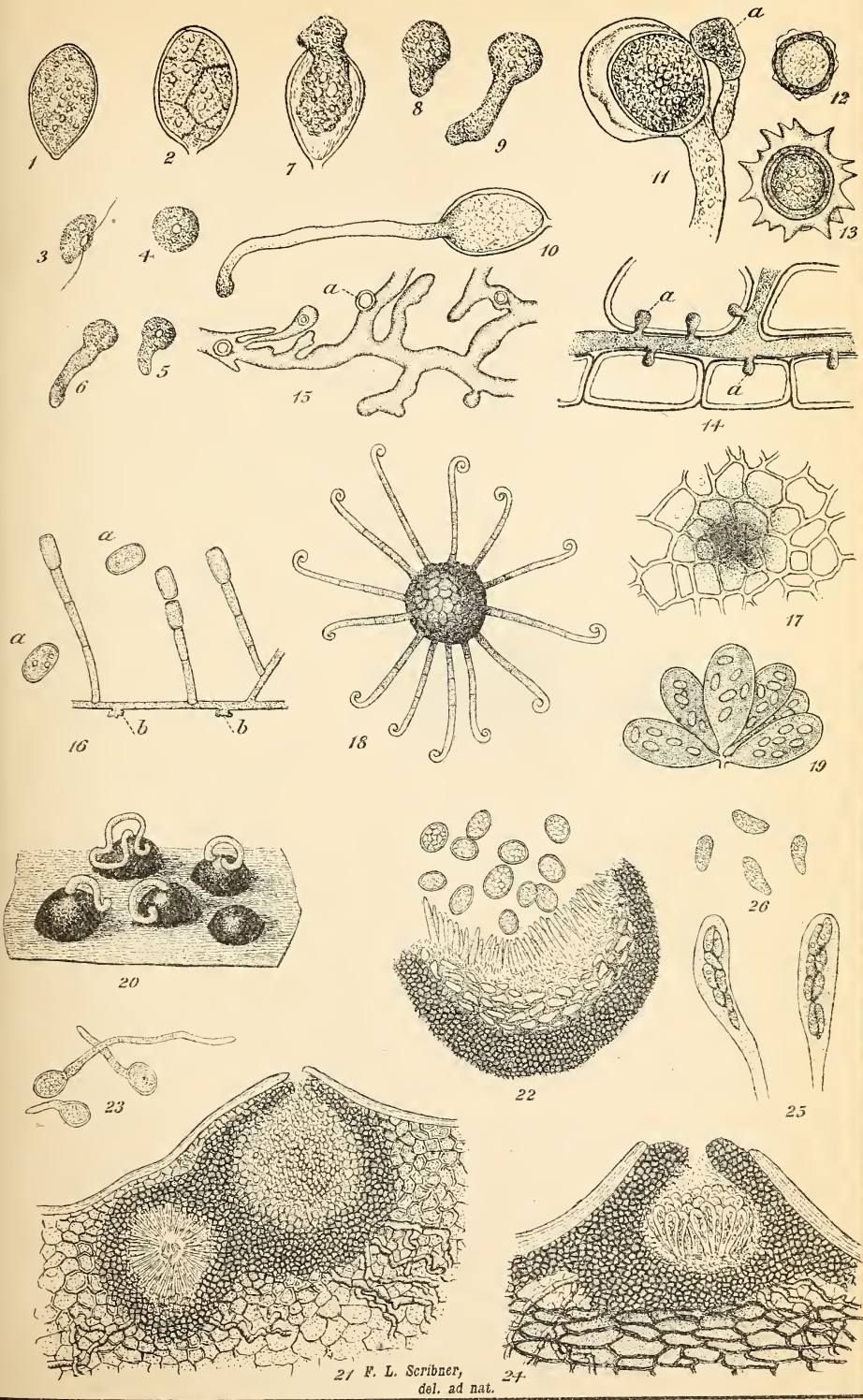
DOWNY MILDEW ON THE BERRIES.

(From a Photo. by Clifford Richardson.)

A. Hoen & Co. Lithocaustic, Baltimore.

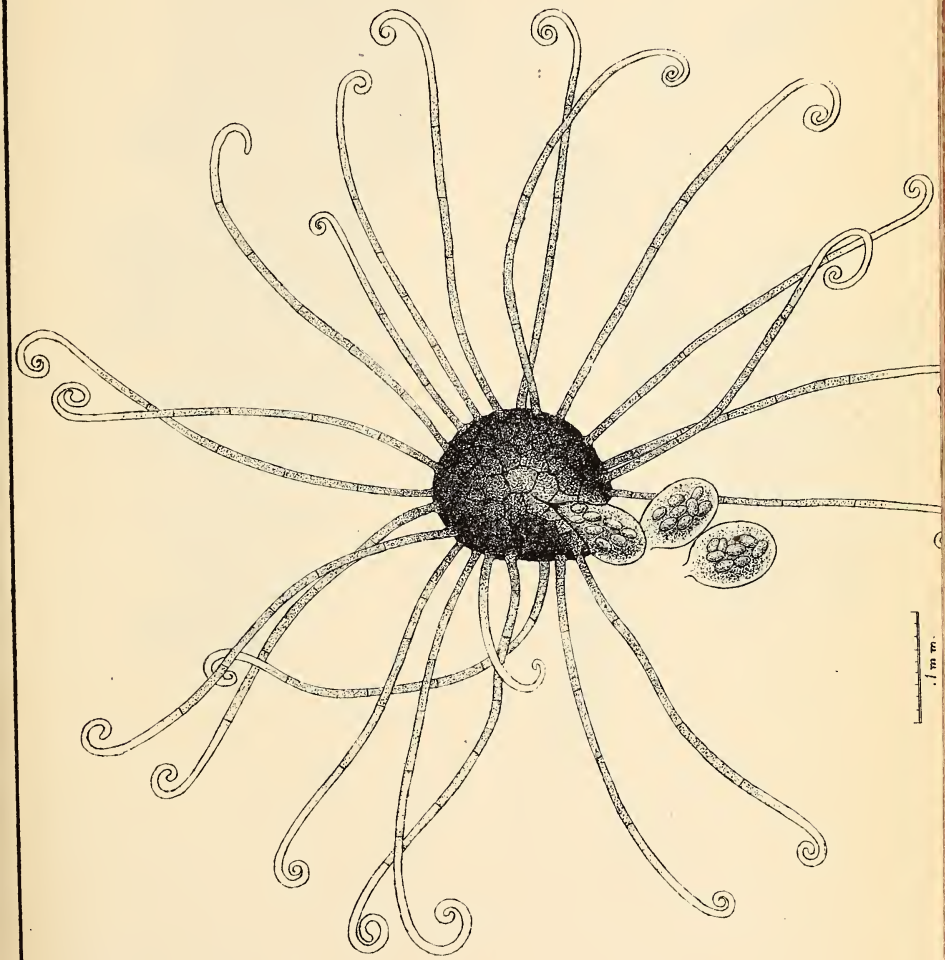
BLACK ROT OF THE GRAPE.

(From a Photo. by Clifford Richardson.)



BELL BROS., PHOTO-LITHOGRAPHERS, WASHINGTON.

THE MILDEWS AND BLACK-ROT OF THE GRAPE.



F. L. Scribner,
del. ad nat

BELL BROS., PHOTO-LITHOGRAPHERS, WASH.

UNCINULA OF THE GRAPE-VINE.

Geo. Marx. fecit.

A. Hoen & Co. Lithocaustic, Baltimore

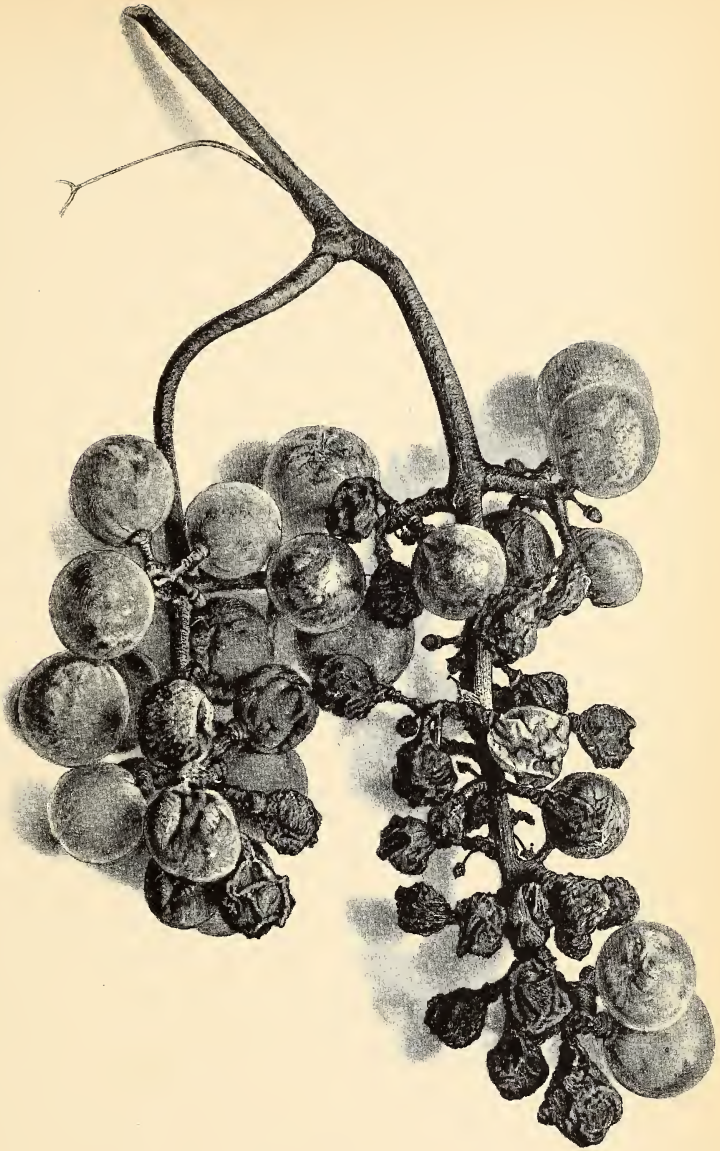
DOWNY MILDEW.

Peronospora viticola.

A. Hoen & Co. Lithocaustic, Baltimore.

DOWNY MILDEW ON THE BERRIES.

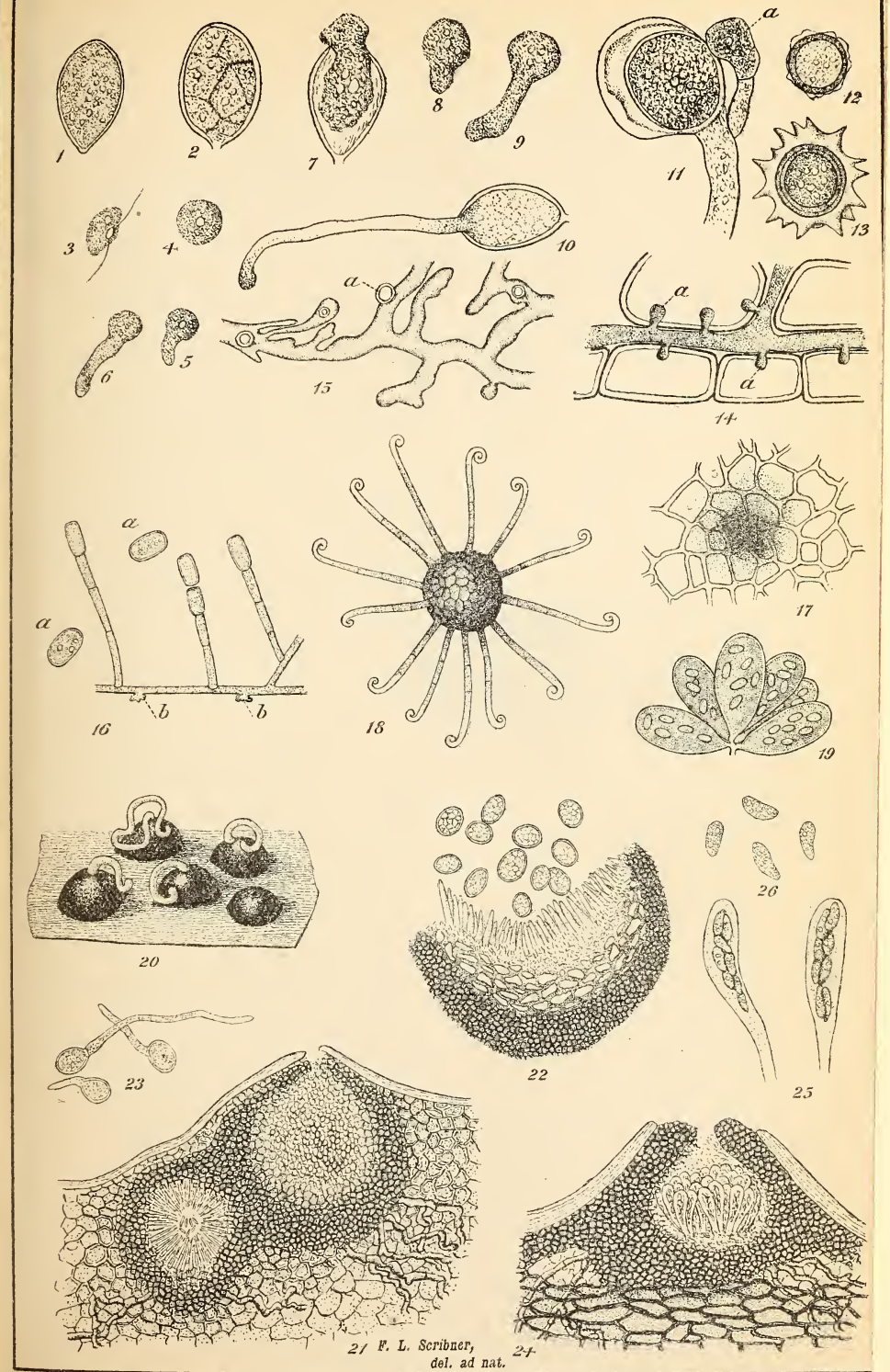
(From a Photo. by Clifford Richardson.)



A. Hoen & Co. Lithocaustic, Baltimore.

BLACK ROT OF THE GRAPE.

(From a Photo. by Clifford Richardson.)



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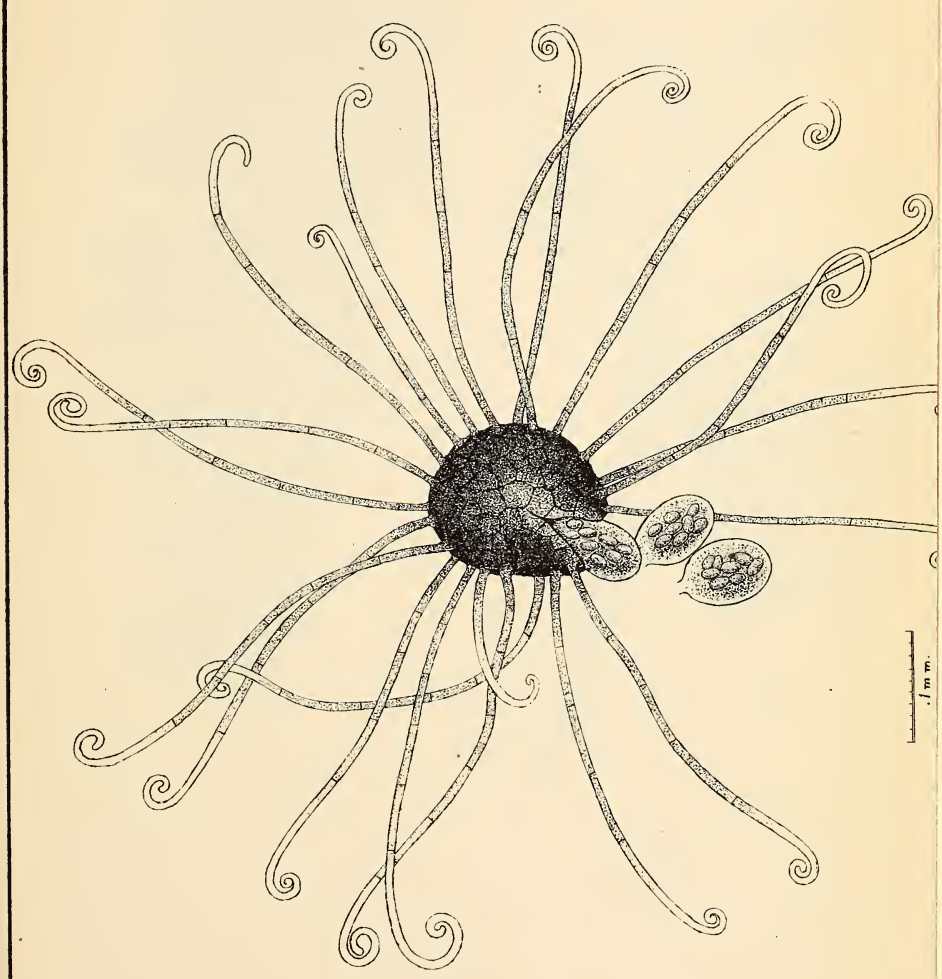
THE MILDEWS AND BLACK-ROT OF THE GRAPE.



F. L. Scribner,
del. ad nat

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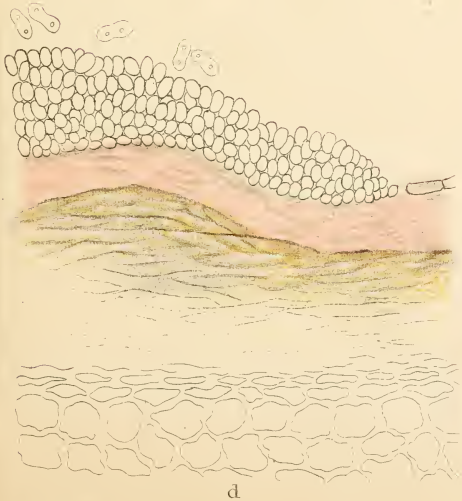
UNCINULA OF THE GRAPE-VINE.



Geo. Marx, fecit.

A. Hoen & Co. Lithocaustic, Baltimore.

ANTHRACNOSE.

Sphaceloma ampelinum.

Geo. Marx fecit.

A. Hoen & Co. Lithocaustic. Baltimore

DISEASES OF THE GRAPE LEAF.

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